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BOSTON HIGH PRESSURE FIRE SYSTEM AND GENERAL PROBLEM OF SPECIAL FIRE SERVICE.

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The Boston high pressure fire system, as now proposed, will protect approximately one square mile of territory covering practically the entire congested value district of the city. It will consist of eight pumping units in three separate stations with 19 miles of mains. It is designed to operate, if the necessity should arise, at a pressure of 300 lb. to the square inch.

Two stations with four pumping units, 11.75 miles of mains and 313 hydrants have been in service for the past seven months, furnishing approximately two thirds the measure of protection which the completed system will afford.

A description of the existing system follows: —

Pumping Station No. 1.

Located in a fireproof isolated area, in the basement of the Lincoln Power Station of the Boston Elevated Railway Co., corner of Commercial and Battery Streets; fire hazard very slight.

Equipment includes two Worthington 3-stage double suction centrifugal pumps, each direct connected to a Westinghouse 750 h.p. steam turbine of the horizontal impulse type, operating at 1 165 r.p.m. with steam pressure of 175 lb., atmospheric exhaust.

Two 16-in. suction mains, both connecting with low service distribution system of city (pressure 50 to 60 lb.) one of them also connecting with high service distribution system (pressure 85 to 90 lb.). One 16-in. suction main, connecting with large intake conduit supplying salt water from harbor to Boston Elevated power station for condensing purposes, provides an emergency salt water supply. Two 16-in. discharge mains, each equipped with a Venturi meter, extend from the station to the H. P. F. distribution system. A centrifugal vacuum pump, with 75 gal. priming

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tank, driven by a 10 h.p. 220 volt D. C. motor is provided to prime the fire pumps when suction is taken from salt water.

A vertical centrifugal single stage sump pump, driven by a 220 volt D.C. motor, takes care of any leakage, etc., within the station.

The water piping is of cast-iron with flanged joints, each piece of pipe in force main being separately tested at a pressure of 600 lb. per sq. in. before being assembled. A 4-in. by-pass between suction and discharge piping equipped with the necessary check valves and meter, insures the absence of air in the system and provides means for measuring the leakage.

The principal control valves on the piping system are electrically operated by Deane Control. Ross regulating valves are installed between the suction and discharge of each pump by means of which the pressures at the pumps are controlled from the operating board, upon which the necessary gages and indicators are installed and from which the valves in the piping system, the vacuum pump and the sump pump are operated.

The turbines are started by hand throttle. Steam is supplied through an 8-in. loop pipe connecting to each end of steam header in the boiler room of the Boston Elevated station, where a battery of twenty (20) Babcock and Wilcox boilers with a total of 10 344 h.p. are located, eight to ten of these boilers being always in service.

At an acceptance test made on December 9, 1921, by the National Board of Fire Underwriters, Pump No. 1 discharged 3 100 gal. per min. at 301 lb. pressure and 4 676 gal. per min. at 201 lb. pressure. Pump No. 2 discharged 3 114 gal. per min. at 300 lb. pressure; 5 164 gal. per min. at 209 lb. pressure and 7 400 gal. per min. at 100 lb. pressure. The two pumps together discharged 6 580 gal. per min. at 292 lb. pressure and 10 266 gal. per min. at 201 lb. pressure. The above performance easily fulfilled the contract requirements.

Pumping Station No. 2.

Located in a fireproof building, constructed for the purpose, within the boiler room of the third station of the Edison Electric Illuminating Co. on Atlantic Avenue, opposite Pearl Street; fire hazard very slight.

The equipment includes two Worthington 4-stage single suction centrifugal pumps, each direct connected through semi-flexible couplings, to Westinghouse 750 h.p. 235 volt D.C. shunt wound interpole motor with a speed range from 860 to 1 050 r.p.m.

Two 16-in. suction mains both connecting with low service distribution system of city (pressure 50 to 60 lb.) one of them also connecting with high service distribution system of city (pressure 85 to 90 lb.). One 16-in. suction main, connecting with large intake conduit supplying condensing water for the Edison station, provides an emergency salt water supply.

Two 16-in. discharge mains, each equipped with a Venturi meter, extend from the station to the H. P. F. distribution system. Two cen-

trifugal vacuum pumps with a 75 gal. priming tank, each driven by 10 h.p. motor, are provided for priming the fire pumps when suction is taken from salt water. One vertical centrifugal single stage motor driven sump pump takes care of any leakage, etc., within the station.

The water piping is of cast-iron with flanged joints, each piece of pipe in force main being separately tested at a pressure of 600 lb. per sq. in. before being assembled. A 2-in. by-pass between suction and discharge piping equipped with the necessary check valves and meter, insures the absence of air in the system and provides means for measuring the leakage.

The principal control valves on the piping systems are electrically operated by Deane control. Ross regulating valves are installed between the suction and discharge of each pump by means of which the pressures at the pumps are controlled.

The switchboard consists of two separate units; one board, designed to handle the heavy starting and running current required for the main motor, contains the connections from the Edison power lines, the bus bars and the secondary contactors for operating the motors. The other, or main control board, consists of four panels — one for each motor, one for the station auxiliaries, and one for the fire alarm. Each motor panel is equipped with drum master switches for operating the main motor, control switches for motor operated valves, gages to indicate suction and discharge pressure, ammeter to indicate amount of current required by motor and wattmeter to register total power required by motor.

In putting a pumping unit into service it is necessary to turn one, two or three master switches, depending upon which suction and discharge mains are to be operated; one master switch only is required to bring motor up to speed, the delivering of water and its pressure being determined by operation of a motor field rheostat and the Ross regulating valve; the control of the latter is through a hand valve immediately in front of each motor panel; the actual position of the regulating valve being shown at all times on a dial visible from the operating platform. Two Venturi meters which register the water pumped into each discharge main, are located immediately beside the control board.

The above arrangement makes it possible for one man to operate easily and quickly the entire equipment in the station. Under normal conditions fire pressure is available within 40 sec. after an alarm is received.

In the event of failure of the fresh water suction supply, the pumps can be primed and ready for service with salt water, in less than three minutes time.

Power for operating the pumps is furnished through cables extending to the pump room from the main switchboard in the generating room of the Edison third station in which are located four 1 600 k.w. and two 800 k.w. direct current generators, and four 1 000 k.w. and one 500 k.w. motor generators. The direct current generators are operated by engines

supplied with steam from a battery of nineteen (19) boilers of 8 400 h.p. capacity, six to ten of the boilers being always under steam. The motor generators receive current at 6 600 volts A. C. from the main station of the Edison Co. in South Boston, delivering it at 250 volts D.C. Three underground transmission lines extend, over two separate routes, to the Edison third station, any two of which have sufficient capacity to operate the entire motor generator installation in the station. Ten direct current tie lines from seven sub-stations in the city are available, on an emergency, to supply 1 500 to 1 800 k.w. to the Edison third station. In addition, two storage batteries with a combined capacity of 9 470 ampere hours, sufficient to run both fire pumps for a period of approximately two hours, are available at the Edison third station.

At a test recently made by the National Board of Fire Underwriters, Pump No. 1 discharged 3 141 gal. per min. at 298-lb. pressure and 4 413 gal. per min. at 202-lb. pressure. Pump No. 2 discharged 3 000 gal. per min. at 300-lb. pressure and 4 407 gal. per min. at 200-lb. pressure. The two pumps operating together discharged 6 580 gal. per min. at 292-lb. pressure. The above performance easily fulfilled the contract requirements.

Distribution System.

The system was designed to deliver 12 000 gal. per min. about any block with a hydrant pressure of 250 lb. per sq. in., and a pump pressure of 300 lb. per sq. in. As a matter of fact, the efficiency of the system exceeds this requirement as during construction the sizes of mains were increased in several instances to provide for different proposed locations of pumping stations. One hydrant is allowed for each 40 000 sq. ft. of area; to secure this distribution, a tracing of the pipe system was superimposed on a sheet of cross section paper in which each square represented 40 000 sq. ft. In this way a sufficient number of hydrants were located to fulfill the requirement.

The system is so designed that, when completed, it will be operated under normal conditions in two parts overlapping each other, or as a duplicate system. This arrangement calls for slightly larger mains, but greatly increases the efficiency in the event of a broken main or hydrant; in such a case, one system would be at once shut off at the pumping station and would remain out of service until the gates required to control the break had been closed, the other system continuing to function at full power; in other words, approximately one half the hydrants would remain in service despite a break in the system.

The system now consists of —

20 140 lin. ft. 20-in. pipe, 1.51 in. thick.
28 808 lin. ft. 16-in. pipe, 1.27 in. thick.
13 081 lin. ft. 12-in. pipe, 1.04 in. thick.

with 313 hydrants supplied by 8-in. pipe 0.8-in. thick.

The straight pipe and special castings are cast-iron excepting branches where the opening from the run is 12 in. or over, in which case semi-steel is used. All pipes were subjected to a hammer test at a pressure of 500 lb. per sq. in.

Two lead grooves are cast in bell end and two in spigot end of each pipe. If it is necessary, during installation of system, to cut a pipe, two lead grooves are required in their proper location near the end of the cut pipe.

The joint material used where unbalanced pressures exist, or might develop, is an alloy of 95 per cent. lead and 5 per cent. tin. Extensive preliminary tests showed that the admixture of tin increased the strength of the joint sufficiently to safely permit tie rods to be dispensed with; a conclusion that has been verified in practice. The joints were made as follows: —

A small pouring pot is kept warm floating in a larger kettle of hot lead; when the joint is to be made, sufficient lead is measured into the small pot and the necessary amount of block tin is added at the last minute. The caulking is done with dog tools using a two handed 4-lb. hammer, a starting chisel and three sets of caulking chisels. The joint is finished or polished off with hand tools.

The mains, in order to avoid as far as possible interference with sewer drains and water services, were laid at a normal depth of 5.5 ft. from the surface of the street to top of barrel of pipe — they were all tested, before joints were covered, for a period of one hour at a pressure of 400 lb. per sq. in. For several years past no difficulty has been experienced in keeping the joint leakage below one half gal. per lin. ft. of pipe joint per 24 hours; in fact, there is usually no leakage of this kind. It is however, impossible to avoid some loss of water at gates and hydrants, and the contract test requirement adopted of 2 gal. leakage per lin. ft. of joint in 24 hours is as small as is practicable.

The post hydrant used was designed and patented by Joseph A. Rourke, now Commissioner of Public Works of Boston. It is of rugged design with $8\frac{1}{2}$-in. barrel $6\frac{1}{8}$-in. main valve, opening against the pressure, and four $2\frac{1}{2}$-in. independently controlled outlets. A notable feature of the design is an auxiliary valve formed by three way cock operated by a covered stem extending along the side of the barrel and terminating in an operating nut at the head of the hydrant. One position of the three way cock closes the waste and equalizes the pressure above and below the main valve in hydrant barrel, the other position opens the waste and closes the connection with hydrant barrel. The hydrant was designed for a normal delivery of 2 000 gal. per min., the loss at this flow being less than 8 lb.

The valves, designed by the department, are of the solid wedge type, bronze mounted, bodies and bonnets of semi-steel of 30 000 lb. tensile strength. All stems are of monel metal, tensile strength 80 000 lb. per sq. in. Each gate was tested for strength at 500 lb. per sq. in., for leakage at 450 lb. per sq. in., and for operation at 300 lb. per sq. in.

Signal System.

Alarms are received in the pumping stations on the usual tapper and gong circuits of the Fire Department alarm system with a perforating register and small gong on the tapper circuit and gong on the gong circuit. For signalling from fires, two special circuits connecting telephone jacks in fire alarm boxes in high pressure fire zone to a Morse key, telephone jack and relay at fire alarm headquarters; the relays operate registers, time stamps, flash lights and sounders. Portable telegraph and telephone instruments, carried by chief officers responding in high pressure districts, are used for code signals for increase or decrease in pressure; these are repeated over a special alarm circuit connecting fire alarm headquarters with both stations; Morse keys and relays operating perforating registers and red flash light are provided at headquarters and each station; headquarters has a tapper and time stamp and each station an 8-in. turtle gong. Orders from one station to the other for the operation of additional pumps are transmitted directly over this circuit. Fire alarm switchboards in the pumping stations are of slate, with metal mountings; standard fire station keys and switches provide testing facilities on each board. A single telephone line connects the Fire Department telephone switchboard in headquarters with both stations.

All orders are transmitted by telegraph, using special code signals for purposes of record; telephones are used only for confirmation. Signals repeated back for verification.

The system is operated by the Fire Department, the distribution system only being maintained by the Public Works Department.

The two pumping plants complete were furnished and installed by the Westinghouse Elec. & Mfg. Co., George S. Gibbs, Boston representative.

General Problem of Special Fire Service.

A well designed and properly installed H. P. F. system is an invaluable weapon of defense against fire, its notable characteristics being power and dependability.

At times, a simple wooden club may suffice to maintain order; again, a revolver is necessary to effect the same purpose, and again a gatling gun must be called into service to avoid disaster; so in fire fighting, the time is sure to come when the special fire system, like the gatling gun, is indispensable if the fire demon is to be held in check. The ability to furnish a sufficient number of large and uniformly powerful streams, in other words, the power to make every blow a hard blow, is one outstanding advantage of such a system. This does not mean that high pressure must always be carried, but simply that the required volume of water at the necessary pressure is quickly and surely available; in New York 125-lb. pump pressure has been found to be sufficient in approximately 90 per cent. of the fires; in one instance only has 225 lb. been found necessary.

In Boston, during the eight months the system has been in service, 125-lb. pump pressure has not yet been exceeded in approximately 100 fires, none of them, happily, being serious. If the mains of the distribution system are of ample size, the name "high pressures" will prove a misnomer, except in the case of multiple serious fires or of a train of adverse circumstances resulting in a threatened conflagration. When unusual danger threatens, the power is available and under other and normal conditions the system functions most effectively, as a flood of water through large nozzles at a uniform pressure can be very quickly made available.

A second outstanding advantage is the fact that no connections other than those to hydrants are taken, or at least should be taken, from the mains of the system; with the result that *the demands upon it are only those made by the firemen* who know its limitations, and it can be depended upon to function with full power under all conditions. The importance of this feature is apparent when the following story of three recent conflagrations is told.

In Baltimore, 1904, water was found to be flowing to waste more or less freely when the fire was under control, through the following pipes: —

50 — 3-in., 4-in., 6-in. fire pipes,
89 — 3-in., 4-in., 6-in. elevator pipes,
6 — 6-in. service pipes,
29 — 4-in. service pipes,
108 — 3-in. service pipes,
39 — 2-in. service pipes,
24 — 1½-in. service pipes,
52 — 1-in. service pipes.

In Chelsea, 1908, despite an heroic effort to shut off all connections from the distribution system in advance of the fire, a careful estimate shows that approximately 6 700 gal. per min. were flowing to waste and destroying pressure at the height of the fire.

In Salem, 1914, two 4-in. and one 6-in. pipes were wasting approximately 7 200 gal. per min. within 40 min. after the fire started. In addition, one 8-in., six 6-in. and two 4-in. pipes were discharging into broken inside equipment before the fire was under control.

In the three above mentioned cases the inevitable happened; the work of the firemen being fatally handicapped by lack of water due to waste from broken connections, the amount of which, in each case, at least equalled the volume of water delivered on the fire.

While direct permanent connections other than to hydrants are taboo, yet hose connections from hydrants to outside pipes supplying sprinkler systems and standpipes within buildings are of the greatest possible value. This fact has not been properly appreciated, at least as far as its practical application goes. It will be conceded that water from a sprinkler system is more apt to reach the seat of fire than are streams

directed from the outside; why then is it not sane and logical to require that a connection, equipped with pressure gage, be made to the sprinkler system at the outset of a fire, to be used if the pressure on the inside system falls too low for effective service, the sprinkler system, of course, being permanently equipped with the necessary check valves.

The connections from distribution systems are rapidly growing in number and size, due to the increasing demand for sprinkler protection and to the requirements of modern plumbing. The danger of destruction of hydrant service at time of fire must also increase, and the time is not far distant when the high pressure fire system will be considered a necessity in all locations where values are high and buildings congested. It constitutes the best insurance against conflagration yet devised.

With the belief that the opinions of men who actually "chew smoke" in the operation of special fire systems will prove valuable and interesting, the following is submitted: —

Chief John O. Taber of Boston writes: —

"The immense aggregation of values in the buildings and their contents in the business district of Boston, and the possibility of conflagrations, with tremendous losses which effect disastrous results on business and civic growth, are striking arguments in favor of providing the most effective known means of preventing such catastrophies. The structural conditions existant in our city, the occupancies, and other features, tend to produce a high conflagration hazard, particularly in sections which are crowded and poorly accessible. Taken as a whole, the chances for sweeping fires in large cities are considerable, even though the Fire Department be efficient and well maintained. All that is required under certain conditions is the right combination of circumstances to make a fire too large for a department to handle. We had such a combination of circumstances in Boston on August 9, 1910. We have had many more since then in which we have been lucky. Pure luck, that's all.

"With the high pressure system in service, the mains are well looped in sufficient areas, with an ample supply of hydrants in which service will not be affected by the breaking of connections inside buildings, thereby bleeding the system. It has been the tendency in modern fire-fighting to use large penetrating streams, and these alone are effective on a fire, well under way, in the ordinary large area buildings filled with combustible stock. Engine supplies at the present time are not capable of alone furnishing the necessary volume through one of our large nozzles, while one hydrant on a high pressure system will supply four or five such streams.

"To sum up the advantages of the high pressure fire system it means that a large number of powerful streams can be concentrated upon a fire in a much shorter space of time with fewer men and less apparatus than fire engines, and at the same time the protection of the rest of the city would not be weakened to the extent now necessary on multiple alarms from the district covered by the high pressure system. It will deliver its full capacity at any point in the district covered at any desired pressure, and can sustain this pressure indefinitely. It eliminates the confusion entailed in the operation of a large number of fire engines. It further tends to prevent a misunderstanding of orders, and in every manner

simplifies operation. Above all, it provides protection to the high-value district from which about all of our sources, supplies and revenue emanate. It is the greatest insurance against conflagration. It forms an effective barrier against fires starting outside the district, and offers the most efficient check in the district, which might otherwise involve a number of large blocks.

"We have used the H. P. F. system for eight months past, at approximately 100 fires. On arrival at the scene of fire we have found in all cases 125-lb. pressure ready and the service has been 100 per cent. I am satisfied that the use of the system has been such as to stop many of the fires in their incipiency, preventing greater loss than would have resulted without it.

"I go on record as being unqualifiedly in favor of the completion of the present high pressure system."

Asst. Chief Joseph B. Martin of New York City writes: —

"I beg leave to state that the high pressure water distributing system is one which admits of very broad consideration and, in my opinion, considering the highly commendable and efficient result, which stands out paramount on every occasion that the high pressure system has been employed in New York City, one is safely empowered if he refers to it as being the greatest, most efficient and most substantial auxiliary unit for fire-fighting purposes ever employed or installed.

"The extensive fires and conflagrations up to and previous to the year 1904 in many large American cities caused the officials, and among them, New York, to view with alarm the possibility of a repetition of these fires and emphasized the necessity of installing ways and means of protection against such a calamity. The result was the preparation of plans for the introduction of the high pressure service, which was inaugurated in 1904, and completely installed and ready for service in 1908.

"The first high pressure system in Greater New York, installed at Coney Island, demonstrated its value in July, 1908, when it was the dominant factor in extinguishing a conflagration which would, no doubt, have reduced the almost complete frame building construction there to ashes.

"The constant, unvarying efficiency demonstrated by this high pressure system enables and prompts me to highly recommend and urge its installation in any city where water facilities are available and accessible, and while the primary cost of installation is high in a city like New York, magnificent results are embodied in its readiness for immediate use, accessibility for connecting lines of hose to outlets, excellent water delivery and pressure control by independent valves, the simplicity of operation, elimination of smoke as from steam pumpers, ability to operate four or five lines from one hydrant. All of these facts enable me, from my practical association and observance of the high pressure system operation, to highly commend and recommend its adoption as the paramount factor in auxiliary fire extinguishing equipment.

"Another reference that highly commends the efficiency of the high pressure installation is the fact that the district charges imposed by the underwriters were modified and reduced upon risks in buildings and contents located in the high pressure districts.

"And when I recall the night of January 9, 1909, when three very extensive and threatening fires took place at almost the same time, and

all in the high pressure district — fourth alarm, station 122, Hudson and Franklin Sts.; third alarm, station 169, Grand St. and Bowery; fifth alarm, station 265, Broadway and Bleecker St. The pressure at the pumping stations was raised to 225 lb. and it was estimated that 15 000 000 gal. of water was delivered through seventy lines of hose, and it was unanimously agreed that the high pressure had saved the borough of Manhattan from a record conflagration, and I positively verify and corroborate this statement.

"At the Equitable Building fire in 1912, the high pressure system had not been extended to this locality at that time, being only installed as far as Maiden Lane, several blocks north of the Equitable Building, but several 3-in. lines were stretched and even at this distance did very effective work.

"At another serious and extensive fire on 25th St., between 11th and 12th Ave., many 3-in. lines were stretched from the then northern boundary of the high pressure system which extended at that time north only as far as 23rd St. Its operation here was credited with effectively controlling the area of fire on that side.

"And so on through a long list of fires which were controlled and held and checked by the first alarm assignment — four engines, two trucks and a water tower — operating at times as many as eleven and twelve effective streams at a fire which would ordinarily call for a third alarm assignment if the locality was not within the high pressure zone and the excellent water delivery available.

"I respectfully refer also to the recent fire at 110–114 Jane St., where several explosions and falling walls presented a very threatening and dangerous situation. This warehouse extends through from Jane St. to West 12th St.; a very extensive area, and when explosions took place the falling walls almost demolished adjoining residence buildings, and required the use of fifty lines of hose with effective streams from each with pressures of 125 lb. at the start at the pumping station, which I ordered increased first to 150 lb. and then to 175 lb. This excellent pressure was maintained uninterruptedly for nine hours when the fire was under control and not a break was suffered with this exceptional demand on the six pumps which were used in the pumping stations.

"And so on through a long list of fires at which the high pressure water delivery has been used since 1908, there is the one sentiment, and that is unanimous, that it deserves the highest commendation and the most commendable references that can be awarded to any auxiliary fire extinguishing system in existence."

Chief Ross B. Davis, Philadelphia, writes: —

"The many advantages attached to a high pressure system are numerous and can be appreciated all the more after experiencing so many years without one.

"The disastrous conditions and possibly a conflagration may be avoided by the immediate use of the high pressure lines. Some fires gain such headway before arrival of apparatus that it is impossible to get within reach of them without a high pressure stream; especially where the fire reaches such a degree of heat that the surrounding property is instantaneously ignited.

"I recall a large fire happened in the month of February, 1921, which was a four-story brick building with a 200-ft. frontage on a street 80 ft.

wide. The wind was blowing at about the rate of 22 miles an hour down this street. Notwithstanding the direction of the wind, the nature of the contents in this building generated heat to such a degree as to set fire to several buildings across the street, placing our men in a very hazardous position.

"Many fires in upper floors of high buildings can be held and heat waves broken by high pressure lines until you can get your lines in action on the floors where the fire is burning. Extreme caution must be used in handling these lines and especially in the loading of buildings with the weight of water, particularly when working lines in buildings.

"The installation of the high pressure system is invaluable to any city or town and may in time be the means of doing away with the pumping unit in the Fire Departments, which may prove to be more economical.

"The high pressure system, which has been installed to date, has performed such excellent service and has been such a gratifying success that I can not urge too strongly the installation of such system to cover an entire city."

Chief L. H. Elling, Toledo, O., writes: —

"As a Fire Department auxiliary it has proven its great value by permitting the rapid concentration of a large number of powerful streams within the area served, and, by lessening the number of fire engines required to do this, increases the efficiency of the fire service in other parts of the city in case of a second fire.

"The system has fulfilled our fondest expectations whenever we found it necessary to use same in the way of getting plenty of water, at any desired pressure, through short lines of hose, which has enabled us to confine all large fires in the congested district to their place of origin.

"On several occasions we found it necessary to use more water than our combined fire engines could furnish and as the high pressure system uses raw water, it saves the low pressure system that much filtration.

"The system is giving such good service in the territory covered that, in my opinion, it should be extended so that others would receive the benefits from same."

Chief William Russell, Toronto, Canada, writes: —

"I consider such means of combatting fires the most valuable acquisition obtainable and would advocate all large cities installing such protection, expensive as it may be in the beginning. I venture to say that such a plant would repay any large city in no time. I have used ours very effectively at different times and would hate to assume my present responsibility without it to fall back on."

Chief August Emrich, Baltimore, Md., writes: —

"I have to say that the important points in connection with the Baltimore system are as follows: —

"The installation of a steam plant in connection with horizontal, Corliss, twin simple, non-condensing, crank and fly wheel types of pumps.

"The use of all lap-welded, soft, open hearth steel pipe, together with a universal joint designed without gaskets, and which thereby prevents leakage on the system.

"The use of portable hydrants of the type used here makes it possible to take off of any one of four lines any pressure as may be desired, not exceeding the pressure, of course, carried on the main at the time.

"I have no hesitancy in saying that I do not think that a more modern type of high pressure system exists than as installed in the city of Baltimore, and when I say, and as I have shown you, that when pressure of 75 lb. maintained on the line can be raised to 250 lbs. in from 20 to 22 sec. and kept so for the heaviest fire service, I am of the impression that a more practical system for the extinguishment of fires is not in existence.

"The installation of high pressure systems to prevent conflagrations and for the extinguishment of fires in large cities is indispensable, and affords, in my opinion, the most modern method of fire extinguishment possible at this time."

Chief Thomas R. Murphy, San Francisco, writes: —

" San Francisco's high pressure fire system has been constructed as an auxiliary fire fighting system, following the failure of the domestic water supply system after the earthquake of 1906, and as such, it has so far fulfilled every expectation.

" As its name implies, it is not intended to be used as a primary fire fighting force, or to eliminate pumping engines in the department, owing to the fact that its mains cover only certain sections of the city, and its hydrants are in many cases set too far apart for efficient service, but for its real purpose, viz. the reinforcement of the domestic water supply system, it has at very many occasions proved of very great value.

" With 10 500 000 gal. of water stored at an elevation 758 ft. above city base, practically at the geographical center of the city, and delivered by gravity (normally through two zone tanks acting as pressure reducers, but capable of being delivered at a pressure of over 300 lbs. per sq. in. in the down town and congested value districts), its superiority over the domestic supply system as a factor in controlling large fires, can readily be seen.

" Whether or not a high pressure system is indispensable, should of course largely depend upon local conditions and the capacity of the domestic supply system, as far as San Francisco is concerned, the fire of 1906 has demonstrated the inadequacy of its domestic system and for safety, the high pressure system is absolutely indispensable.

" Ever since its completion, some nine years ago, the local high pressure system has been used at every large fire as far as its mains extend, and in every instance has given complete satisfaction."

The accompanying insert sheet gives a list of the existing H. P. F. and auxiliary fire systems in the United States and Canada, with data concerning the principal features of each system. The somewhat wide divergence of design, due in part to local conditions, is notable.

City.	Population U. S. Census 1920.	Date of Installation.	Type of Power.	Gals Min
Atlantic City	50 707	Partly in Service.	Connections to hotel pumps	10
Baltimore	733 826	1912	1 Station, 3 Allis-Chalmers horizontal Corliss, twin simple, non-condensing, crank and fly wheel pumps; 1 Epping Carpenter, horizontal, duplex, direct acting, compound non-condensing (1 000 g.p.m.) pump; 3 Edgmoor water tube boilers, 1 160 h.p. each.	13
Boston	748 060	1921	No. 1 Station, 2 Worthington 3-stage double suction centrifugal pumps direct connected to Westinghouse 750 h.p. steam turbine, horizontal impulse type, 1 165 r.p.m., steam pressure 175 pounds, atmospheric exhaust. No. 2 Station, 2 Worthington 4-stage, single suction, centrifugal pumps, direct connected to Westinghouse 750 h.p. 235-volt, D. C. shunt wound interpole motor, 860 to 1 050 r.p.m.	12 18
Brooklyn	2,018 356	1908	No. 1 Station, five Worthington 5-stage, horizontal, centrifugal pumps driven by General Electric 800 h.p., 6 600-volt, induction motors. No. 2 Station, three units of same type and capacity.	24 40
Buffalo	506 775	Installation in Progress.	1 Station, three 4-stage, centrifugal pumps, 1 500 r.p.m., driven by three 750-h.p. Terry steam turbines, 3 170 r.p.m., steam pressure 225 pounds, speed reduction by set of herring bone spur gears, running in oil.	9
Cincinnati	401 247	1917	Gravity†	10
Cleveland	796 841	1907	1 Station, motor-driven centrifugal pumps	12
Coney Island	...	1905–6	1 Station, 3 Gould triplex pumps driven by Nash gas engines.	3
Detroit	993 678	Installation in Progress.	1 Station, six 4-stage centrifugal pumps driven by 700 h.p. motors.	15
Fitchburg	41 029	..	Gravity†	5
Fort Worth	106 482	1910	1 Steam Station, emergency connection to Distribution System.	5
Jacksonville	91 558	1911	1 Station, motor-driven centrifugal pumps	5
Lawrence	94 270	1906	Gravity†	3
Newark	414 524	1905	Gravity†	3 5
New York Manhattan	2 284 103	1908	2 Stations, each equipped with 6 Allis-Chalmers 5-stage, centrifugal pumps, direct connected to Allis-Chalmers 800-h.p., 6 600-volt, 3-phase, 25-cycle, induction motors, 740 to 750 r.p.m.	36 0 60 0
Miami	29 571	1913	2 Stations, motor-driven centrifugal and steam pumps	5 5
Oakland	216 261	1910	Oil engines geared to centrifugal pumps	2 0
Philadelphia	1 823 779	1903	No. 1 Station, 7 Deane, vertical, triplex, double-acting pumps, 1 200 g.p.m.; each driven by 3-cylinder, 4-cycle, vertical, 300-h.p., Westinghouse gas engine; 2 pumps of same type, 350 g.p.m., each driven by 125-h.p. gas engine.	9 1
		1910	No. 2 Station, 10 Deane, vertical, triplex, double-acting, pumps, 1 200 g.p.m. each; 1 pump of same type 350 g.p.m.; all driven by nine 350-h.p. and one 125-h.p. Westinghouse gas	12 35

LIARY FIRE SYSTEMS IN THE UNITED STATES AND CANADA.

TABLE 1.
N. E. W. W. ASSOCIATION
VOL. XXXVI.
MC INNES ON
BOSTON HIGH PRESSURE
FIRE SYSTEM.

	Gals. per Minute.	Maximum Pressure Pounds.	Lin. Feet of Mains.	Sizes of Mains in Inches.	Type of Mains.	No. of Hydrants.	Type of Hydrants.	Suction Supplies.	Cost of System.	No. of Acres.	Cost per Acre.
.....	10 000	To Cover Board Walk District.									
imple, Car- n-con- oilers,	13 000	250	46 700	10–24	Lap welded soft, open, hearth steel with special universal joint.	226	Flush with Ross portable service head.	One from distribution system. One from salt water.	$534 050*	230	$2 300*
cen- h.p. steam cen- h.p. 1 050	12 000 18 000	300 200	62 029	12–20	Cast iron double lead groove in bell and spigot, special joint alloy.	313	Post Compression Independent Gates.	Two from distribution system, one from salt water, in each station.	1 370 000	480 approximate	2 854
ifugal nduc-	24 000 40 000	300 200	..	12–20	Cast iron double lead groove in bell and spigot.		Post Compression Independent Gates.	Two from distribution system.	1 384 500	1 420	975
p.m., p.m., rring	9 000	300	..	12–20	Cast iron with "Universal" machined bolted joints.		Post Compression Independent Gates.	..	..	..	..
....	10 000	150	..	8–20	..	..	..	..	..	..	..
....	12 000	270	37 665	8–20	..	..	..	..	170 000*	338	500*
gines.	3 600	150	..	8–16	..	..	..	..	90 000	147	612
h.p.	15 000	300	62 099	8–20	Cast iron bell and spigot.	270	Post Compression Independent Gates.	..	..	..	..
....	5 000	180	28 250	8–16	..	..	..	..	50 000	346	144
tion	5 000	100 to 200	42 200	8–16	..	106	..	..	..	245	..
....	5 000	175 to 192	22 688	8–20	..	90	..	..	58 000	180	537
....	3 000	134	10 200	10–12	..	39	..	..	..	120	..
...	3 500	160	15 000	20–30	..	52	..	..	135 000	303	446
age, h.p., 750	36 000 60 000	300 200	289 500	12–24	Cast iron double lead groove in bell and spigot.	1 200	Post Compression Independent Gates.	Two from distribution system. One from salt water.	3 280 000* 3 950 400	1 430 ..	2 300* 2 763
...	5 500	175	7 450	8–16	..	29	..	..	..	136	..
...	2 000	200	12 000	10–14	..	..	..	..	146 000	..	..
aps, cal, ype,	9 100	300	85 008	8–20	Cast iron with flanged bolted joints.	289	Gate valve and Post Compression.	From Delaware River.	3 030 000*	512	1 150*
ing, m.; gas	12 350	300	163 680	8–20	Cast iron with Universal ma-	600	Post Compression with	From reservoir of 5 000 000			

Detroit	993 678	Installation in Progress.	1 Station, six 4-stage centrifugal pumps driven by 700 h.p. motors.	15 000	
Fitchburg	41 029	..	Gravity†	5 000	
Fort Worth	106 482	1910	1 Steam Station, emergency connection to Distribution System.	5 000	100 20
Jacksonville	91 558	1911	1 Station, motor-driven centrifugal pumps	5 000	175 19
Lawrence	94 270	1906	Gravity†	3 000	
Newark	414 524	1905	Gravity†	3 500	
New York Manhattan	2 284 103	1908	2 Stations, each equipped with 6 Allis-Chalmers 5-stage, centrifugal pumps, direct connected to Allis-Chalmers 800-h.p., 6 600-volt, 3-phase, 25-cycle, induction motors, 740 to 750 r.p.m.	36 000 60 000	
Miami	29 571	1913	2 Stations, motor-driven centrifugal and steam pumps	5 500	
Oakland	216 261	1910	Oil engines geared to centrifugal pumps	2 000	
Philadelphia	1 823 779	1903 1910	No. 1 Station, 7 Deane, vertical, triplex, double-acting pumps, 1 200 g.p.m.; each driven by 3-cylinder, 4-cycle, vertical, 300-h.p., Westinghouse gas engine; 2 pumps of same type, 350 g.p.m., each driven by 125-h.p. gas engine. No. 2 Station, 10 Deane, vertical, triplex, double-acting, pumps, 1 200 g.p.m. each; 1 pump of same type 350 g.p.m.; all driven by nine 350-h.p. and one 125-h.p. Westinghouse gas engines, same type as No. 1 Station.	9 100 12 350	
Providence	237 595	1897	Gravity†	7 000	
Rochester	295 750	1874	No. 1 Station, 2 steam pumps, one 2-stage, centrifugal pump driven by steam turbine. No. 2 Station, motor-driven, 3-stage, centrifugal pump.	9 000	
San Francisco	506 676	1912	Gravity. 10 500 000-gal. reservoir with 2 pumping stations in reserve equipped with 8 Byron-Jackson 4-stage centrifugal pumps, direct connected to Curtis 750-h.p., horizontal, non-condensing steam turbine, 250-h.p. Babcock and Wilcox boilers.	32 000	
Toledo	243 164	1917	1 Station, four 5-stage, horizontal, centrifugal pumps, direct connected to 550-h.p., 3-phase, 25-cycle, 4 000-volt motors.	8 000	
Toronto	515 000	1909	1 Station, 2 McDugall, 2-stage, centrifugal pumps, direct connected to Westinghouse Parsons 1 500-h.p. condensing, multiple stage, impulse type, steeam turbines.	8 333	
Winnipeg	178 304	1907–8	1 Station, six triplex, double-acting pumps driven by 4 Crossley, 2-cylinder, tandem, gas engines, 540 h.p. each; 2 Crossley, 2-cylinder, tandem, gas engines, 250 h.p. each; one producer gas plant consisting of 2 Crossley type producers, 500-h.p. each and 2 of 1 000 h.p. each; city gas also available. Two motor-driven centrifugal pumps	10 800 4 320	
Worcester	179 754	..	Gravity†	5 000	

* Exclusive of pumping station and equipment.

† System consists of extension of pipes from High Service into area covered by Low Service.

15 000	300	62 099	8–20	Cast iron bell and spigot.	270	Post Compression Independent Gates.	..	..	..	..
5 000	180	28 250	8–16	..	..	..	..	50 000	346	144
5 000	100 to 200	42 200	8–16	..	106	..	..	..	245	..
5 000	175 to 192	22 688	8–20	..	90	..	..	58 000	180	537
3 000	134	10 200	10–12	..	39	..	..	..	120	..
3 500	160	15 000	20–30	..	52	..	..	135 000	303	446
36 000 60 000	300 200	289 500	12–24	Cast iron double lead groove in bell and spigot.	1 200	Post Compression Independent Gates.	Two from distribution system. One from salt water.	3 280 000* 3 950 400	1 430 ..	2 300* 2 763
5 500	175	7 450	8–16	..	29	..	..	..	136	..
2 000	200	12 000	10–14	..	..	..	..	146 000	..	..
9 100	300	85 008	8–20	Cast iron with flanged bolted joints.	289	Gate valve and Post Compression.	From Delaware River.	3 030 000*	512	1 150*
12 350	300	163 680	8–20	Cast iron with Universal machined bolted joints.	600	Post Compression with Independent Gates.	From reservoir of 5,000,000 fed by City service.			
7 000	116	29 400	12–24	Cast iron two lead grooves in bell.	89	Flush.	From City Reservoir.	143 136	358	400
9 000	140	102 960	4–20	Cast iron bell and spigot.	..	..	..	..	..	..
32 000	300	508 000	10–20	Cast iron two lead grooves in bell.	..	Post Compression	Reservoir and San Francisco Bay.	..	5 300	..
8 000	300	22 625	10–16	Cast iron bell and spigot.	66	Post Compression Independent Gates.	Two intakes from Maumee River.	..	140	..
8 333	300	40 770	6–20	Cast iron bell and spigot.	146	Post Compression Independent Gates.	Two intakes from Toronto Bay.	500 000	287	1 742
10 800	300	15 840	8–20	Cast iron with double lead grooves bell.	..	Post Compression Independent Gates.	Intake from Red River.	650 000	275	2 364
4 320	150	..	..	..	..	..	..	..	..	..
5 000	165	100 320	8–30	Cast iron.	..	Post.	..	..	1 380	..

ow Service.

HIGH PRESSURE FIRE SYSTEMS FROM THE UNDERWRITERS' VIEWPOINT.

G. W. BOOTH*

[*Read September 15th, 1922, at New Bedford, Mass.*]

Losses resulting from conflagrations are those most dreaded by the insurance companies; they correspond in fire insurance to what a widespread attack of the plague would be to life insurance. It was following the Baltimore conflagration in 1904 that the National Board of Fire Underwriters organized the Committee of Twenty, superseded two years later by a standing Committee on Fire Prevention, one of the principal functions of which had been to advise on means whereby conflagrations might be averted. The Baltimore High Pressure System was installed as a result of the experience in combating the 1904 Conflagration in that city. and the San Francisco System correspondingly after the 1906 Conflagration,

Conflagrations spread either by the generation of a heat wave of such intensity that everything combustible in its path is involved, or by means of flying brands carried by the wind far in advance of the origin of the fire and setting fire to combustible roofs or porches. The first type of conflagration is that of which we must think in considering the installation of High Pressure Fire Systems, since most of them occur in high value congested districts and it is only in such districts that the expense of installing and maintaining a separate fire main system can be warranted. There is of course much doubt as to whether such a system or any other fire fighting facility will enable a fire department to make a direct stop of a conflagration well started; probably not, since the heat wave is so intense for some distance in advance of the fire as to prohibit a stand. But it will at least facilitate a narrowing and checking of the fire at strategic points, and should serve to prevent a threatening fire from assuming conflagration proportions, as it has in fact been reported as doing in one or more cases in Baltimore.

An inspection of the list of cities in which separate fire main systems have been installed shows that 9 out of the 18 cities which have installed such systems with special pumping stations to supply them have a population in excess of 400 000; four of the other 9 are in excess of 200 000 and most of the others either present special fire protection problems or were able to take advantage of favorable conditions to minimize the cost of installation, or of maintenance, or both. In this comparison are not included

* Chief Engineer, National Board of Fire Underwriters, New York City.

those cities which have made extensions of the domestic high service systems into congested value sections at lower elevations. Such extensions have been made in Worcester, Providence, Newark, N. J., Fitchburg, Lawrence, and a few other cities, and furnishing from 3 000 to 8 000 gal. per minute at initial pressures ranging from 130 to 180 lb. must be considered as highly valuable auxiliaries to other fire-fighting facilities.

An interesting form of development is that in Atlantic City, where the high value hotel district is protected in part by a system of mains and hydrants installed by the city, with supply from the fire pumps in each of the hotels under protection. A somewhat similar plan was established a number of years ago by the proprietors of the locks and canals for the protection of the mill district in Lowell, Mass., and certain of the mills in Lawrence have connections from their individual fire pumps to a common main running the full length of the plants. While this plan has some disadvantages as compared with a system having supply and distribution under single management and control, it appears to be well suited to serve adjoining and common interests where the more expensive complete installation is not practicable.

A few years ago, when the question of installing a system in Boston was being discussed, the National Board prepared a pamphlet entitled "The Desirability of a High Pressure Fire System in the City of Boston." We had perhaps more difficulty in convincing ourselves that such a system was desirable in Boston than in most cities of its size, in spite of its narrow streets and congestion of buildings; because the city of Boston had already an unusually good system for supplying water to fire engines, besides having extensions from the domestic high service for serving automatic sprinkler equipments throughout most of the congested value sections. The arguments in that pamphlet may be summarized as follows, and will apply with equal or greater force in other large American cities: —

(1) The immense aggregations of buildings and contents in the business district of metropolitan cities, and the possibility of conflagrations involving tremendous losses and disastrous effect on business and civic growth, dictate the most effective known means of preventing such catastrophies.

(2) A large number of powerful streams can be concentrated on a fire in much shorter time and with fewer men and less apparatus than with fire engines.

(3) The protection of the rest of the city will not be weakened to the extent now necessary on third and fourth alarms from the district covered by the system.

(4) It will deliver its full capacity at any point in the district covered and at any desired pressure and can sustain this pressure as long as wanted.

(5) It eliminates the confusion entailed in the operation of a large number of fire engines, tends to prevent the misunderstanding of orders, and in every way simplifies operation.

(6) It provides protection to the congested value district even with a general alarm fire under headway in another part of the city, and forms an effective barrier against fires starting outside the district, while also affording the most efficient means of checking fires in the district which might otherwise involve a number of blocks.

Concerning the first of these items, I would not have you believe that there are no other effective and practicable means of offsetting the conflagration hazard. I recently had the pleasure of a discussion on this subject with the chairman of the London City Council Committee on Fire Briades, which corresponds to the position of Fire Department Commissioner in American cities. He had been in New York about a week and was wondering why it was that, in spite of the vastly greater numerical and apparatus fire department strength as compared with London, we had such disastrous and destructive fires. When questioned, he stated what undoubtedly constitutes the answer to his problem, that in London the building ordinances prohibit any building more than 80 feet high, require fire walls to subdivide floor areas, and compel the protection of all openings in elevator shafts and other connections from floor to floor. These requirements, together with protection on exposed openings in exterior walls and with automatic sprinkler equipments in buildings of hazardous occupancy, would go very far towards making entirely unnecessary the powerful high pressure systems we are considering. However, the present situation and trend of development in American cities are such that structural conditions will for many years to come require the strongest possible fire protection facilities to offset them.

It is not an impossibility, even without a high pressure system, to concentrate numbers of powerful streams on a threatening fire in a large area building, as has been proved again and again in the city of Boston, where the water supply is ample and readily available and the fire department trained and accustomed to do that very thing. However, it is not a very common practice nor one readily accomplished without good training, as has been demonstrated in a number of cases recently, at fires which would have been much less destructive had these powerful streams been used. It is not so difficult to accomplish for the modern department equipped with automobile pumping engines as it was in the days of steam fire engines, which are much more awkward to handle and less able to maintain the pressure and discharge at which they are rated. However, even the automobile fire engine is at a disadvantage, since the largest of those in common use has a rated capacity of 1 000 gal. per minute at 120 lb. net pressure, and we may reasonably expect from each of the closer hydrants of a high pressure system an average of 2 000 gal. per minute at any pressure up to 250 lb. Also, such a system is much more flexible in operation as respects relocation of hose lines and regulation of pressures on individual lines than one which involves the use of fire engines.

Since July, 1908, when the high pressure fire system was put in service in Manhattan, the most extensive use made of it was in January, 1909, when it was brought into service for five simultaneous fires, three of them of more than usual severity, and one particularly so. At the extreme, seven pumps were being operated, delivering 33 500 gal. per minute against an average pressure of 225 lb. at the pumps and 205 lb. at the hydrants. Forty engine companies were called, including more than 600 men, and all the water thrown on the fire was from the high pressure system.

The system was also used on the occasion of the Equitable Building fire, and at a difficult fire in a general storage warehouse fire on Jane Street in July, 1922; because of a disastrous explosion in the early stages of this fire, it was not considered safe for firemen to remain in the building, and the fire was therefore drowned by streams from the outside; at one time sixty large streams, using a total of over 30 000 gal. per minute were in service, at a pressure of about 200 lb. at the hydrant, and a total of 87 000-000 gal. of water is reported to have been used. Each of these streams would require, if fire engines were used, the services of one fire company, whereas each company can lay and handle at least two or three lines from a high pressure hydrant to turret nozzles or water towers. It follows, therefore, that fewer companies will be required for fires calling for large quantities of water, and a much smaller part of the city will be stripped of its normal protection.

Conversely, in the event of a general alarm fire in another part of the city sufficient companies to man a reasonable number of streams will always be left in service for the protection of the district which is covered by the high pressure system; and should a fire originate outside the district and threaten the district itself, the concentration of streams which can be effected would constitute a means whereby such an exposure fire could be checked or narrowed with better success than in any other way, except perhaps by the interposition of sprinklered buildings, well provided with window protection; these latter are not frequent enough at present on the outer boundaries of most of our congested value districts to constitute a very reliable line of defence.

It is uncanny to witness the fighting of a large fire when only streams from a high pressure fire system are used. Instead of the noise and the apparent confusion when either steam fire engines or automobile pumping engines are used there is only the swishing noise of the streams as they emerge from the nozzles or strike the walls of the building. This, of course very much facilitates the issuing of orders by chief officers and simplifies operation in every way.

I shall not attempt to discuss definitely the question of reduction in fire insurance rates which has accompanied the completion of separate fire main systems in different cities. The National Board of Fire Underwriters has no jurisdiction and exercises no control in matters of this nature, and it is difficult to make a statement as to the amount of credit

which is in some cases a percentage of the base rate and in others a flat reduction; in any case, the matter is one to be decided upon by the insurance organization having local jurisdiction. In most cases, no credit is allowed in rates on buildings equipped with automatic sprinklers, in some cases none is allowed on stocks but only on buildings, and in others the principal credit relates to the item covering exposure hazard from other buildings.

JOINT DISCUSSION.

MR. BOOTH. There is one point I overlooked at the time of writing my paper which is that a good many of the insurance companies, having doubt as to the adequacy of existing fire protection, will write greater lines on buildings after the completion of a high pressure system than they were willing to before. I think that was the case in the city of Boston. Some of the larger companies, which had limited their lines quite materially, felt that the city was enough safer after the system was installed to warrant their writing considerably larger lines.

I have not gone into detail on a great many things that occurred to me, thinking very likely there would be questions that would come up which would bring out those points. One that does occur to me right now as to operation is that in some cities, as you have noted from Mr. McInnes' paper, the system is used on all fires that occur within the area protected. In other cities it is used only on second or greater alarm fires. It is my opinion that the oftener it is used the more familiar the firemen become with its use, and the more likely they are to operate it effectively when the real severe test comes. For that reason we have always felt that it should be used on all alarms.

MR. J. M. DIVEN.* What pressure is ordinarily maintained between alarms?

MR. MCINNES. About fifty-five pounds.

MR. DIVEN. That would rather discourage a man who wanted to get it for some other use.

MR. MCINNES. Mr. Booth spoke of the uncanniness of operation of the high pressure system. That feature was strikingly exemplified to me at a fire in the sixth or seventh story of a building on lower Broadway about two years ago. The firemen ran several lines inside the building quietly, quickly and methodically; they also connected on the outside to fire pipes in the building. The smoke and flame which had been pouring out of the windows suddenly stopped. A visit to the pumping station showed that the delivery of water at first was 1 200 gal. per min. When the stage was properly set it jumped up to 7 000 gal. per min. and the fire gave out. The only excitement was afforded by a couple of thrilling rescues.

* Secretary of American Water Works Association.

MR. CARLETON E. DAVIS.* What is the limit beyond the fire hydrant that you can use this high pressure system?

MR. MCINNES. We figure 400 ft. under ordinary conditions. Undoubtedly effective work can be done 1 000 ft. away, using two or more lines siamezed.

MR. BOOTH. There have been occasions where lines have reached 1 000 ft. in New York. In the Equitable Building fire, the pipe system was not extended to that point at the time of the fire, but it was close enough to enable effective use to be made of it. Of course you have to draw the line somewhere, and we have considered 400 ft. as a fair distance from the nearest hydrant, within which you would get reasonable normal protection.

MR. WILLIAM W. BRUSH.* As I recall, when we were working on the installation of the New York system, we estimated on 600 ft. as the extreme distance from a hydrant that we would consider the high pressure system to furnish effective protection. I want to ask Mr. McInnes whether he has any connection at all between his high pressure pipe system and his domestic lines, except from the pumping stations.

MR. MCINNES. None whatever, Mr. Brush, with the exception of the small by-pass through the station, to keep pressure on the high pressure fire system, with check valves, which we use to keep air out of the system, to be sure there is no air in the hydrants, and also use to measure the leakage. That is the only connection of any kind anywhere in the system.

MR. BRUSH. There is no other connection to any private system which could be put in use by the Fire Department, except by stretching hose?

MR. MCINNES. None whatever.

MR. BRUSH. In Brooklyn, we have two connections, between the high pressure and low pressure systems, so that the high pressure system can be used as an auxiliary service in case of a break down of one of the domestic pumping stations. Those connections have two valves on each connection and between the valves we have a drain pipe to take care of any seepage which may occur between the two systems.

If we ever have to put salt water in the system, and we doubt if we ever do, the possibility of any salt water getting in the domestic services through these connections is obviated by the drains at these connections. We have recently arranged to put in a connection that will be available for the Navy Yard in Brooklyn. That connection terminates in an open pipe, and the Navy Yard has to provide a large size special hose that can be used to connect the two systems. The naval authorities are required to notify both the Fire Department and the Water Department before they place the connecting hose. That is something that is very special, and we believe that connection is amply safeguarded in as much as there is no direct connection between the two systems, but this special hose connec-

* Chief, Bureau of Water, Philadelphia, Pa.
* Deputy Chief Engineer, Bureau of Water, New York.

tion can be connected up so that the Navy Yard in Brooklyn can have the high pressure water in case their own high pressure system fails.

Down at Coney Island, where there is the first high pressure system installed in New York, we had a number of connections to the amusement parks. These connections were put in at the request of the Fire Department, the proprietors of the amusement parks having urged the placing of such connections. After the Dreamland fire, if I recall correctly, the Fire Department then requested that these connections be closed and sealed because the Fire Department experienced trouble with the unauthorized use of some of the hydrants.

In Manhattan there have been cases where through error, intentional or otherwise, there have been small connections made from the high service into buildings, and the evidence tends to show the possibility of there being one or more such connections still existing on the system, but we have been unable to locate them. They, of course, do not represent any connection which would affect the delivery of the system.

We had rather an interesting experience with a couple of hydrants about which there is some difference of opinion as to the cause of the trouble. In April of 1918 the fire chief reported that at a fire the flow from one hydrant suddenly ceased. An examination was made of the hydrant immediately after the fire and there was nothing found to be the trouble with it. The hydrant was taken apart the following day and everything was apparently all right. At that time the only cause for the obstruction of flow through the hydrant that appealed to me was the possibility that ice had formed at a high point in the system, become dislodged, floated into the branch and cut off the flow. This spring we had a similar case as far as the cutting off of the flow was concerned. The pressure suddenly dropped from about one hundred fifty pounds to fifty pounds on one hydrant. We had been getting ample flow from the hydrant and several lines had been taken off this hydrant. The hydrant was examined within a few hours and then taken apart the following morning. Here again the hydrant was in perfect order when it was taken apart. The only explanation that I could personally give was that ice had floated in and temporarily closed the branch or hydrant valve opening. Those are the only two instances of that character, and the only instances that I can recall where there was any stoppage of flow through any one of the several thousand hydrants that we have on the system. Chief Kenyon did not agree with me on the ice theory in the first instance. In the second instance I do not recall that he made any comment.

PRESIDENT BARBOUR. What depth are the pipes laid? Are they all the same?

MR. BRUSH. Four and one half feet. There are some places where they come up within two feet of the surface. I think 18 in. is the minimum depth we have from the surface to the main. Now, we have had one instance where the high pressure main was frozen solid, which was during

the severe winter of 1918. The pipe was cracked and had to be replaced. We have not had any instance where the general flow from the mains has been affected, as far as could be observed, by ice formation.

MR. DIVEN. Other hydrants in the neighborhood were working?

MR. BRUSH. Yes, there were several hydrants working on these two fires, and they worked perfectly, so that there was no trouble in the flow of water through the system. At the Jane Street fire one of the two pumping stations, during the height of the fire, experienced a break in a 10-in. check valve. The check valve suddenly seated and blew the casing top off, and the result was that the station was very thoroughly sprayed with water. The load was quickly transferred over onto the other station, and the Fire Department never knew anything about it. The station itself could probably have been kept operating on the fire if it had been essential to do it. Within an hour it was back again on the regular service. But this shows how a rather serious accident can occur in the pumping station and still keep the pressure up. There has never been a case where the stations have failed to function.

The Coney Island station, using gas engines, has not been as satisfactory as the electrically operated stations. We have had trouble there with engines and with pumps from time to time on large fires. I think that plant is in better shape to-day than it ever has been before. There have been changes made to make the pumps and the engines more reliable. But there we have had a lessening of the delivery of the station, so that the pressure has been low when the Fire Department desired service on one or two of the largest fires.

In the main system of Brooklyn, where we have two stations, we connected the Catskill system to the mains and put about one hundred pounds on the system two or three years ago, and since then have had less than a dozen runs a year with the two stations combined, so that in Brooklyn, where the Fire Department normally ask for 75 lb. at the start of the fire, the 100 lb. pressure takes care of all except about a dozen fires. The protected area runs several miles along the water front and a mile deep in the main district of the borough.

Also in Brooklyn the system was laid out so as to check the conflagration in the high pressure district rather than to eliminate the use of the steam or other power driven fire engines, and recently the Fire Department have asked us to extend the system so that they can do away with calling the fire engines in case of fire within the high pressure district. It would mean installing mains in intermediate streets that are perhaps six hundred or seven hundred feet apart.

We have one distinct difference in our system from the Boston system, and that is that we operate the plants, and in Boston the Fire Department operates the pumping plant. Also we get our messages entirely over the telephone; and, as I understood Mr. McInnes, they use the telegraph system and confirm over the telephone. We felt when the system was in-

stalled that the Water Department was more likely to have men suitably trained to look after the operation of the pumping station than the Fire Department, and while the Fire Department thought otherwise, there was not any very serious objection made to our department maintaining and operating, as well as constructing the high pressure stations, and I think to-day that the Fire Department in New York is perfectly satisfied with the system now followed. There never has been any friction, and the stations have always been able to give the water required, other than at Coney Island where the demand exceeded the station capacity.

MR. MCINNES. Mr. Brush, in the case of the hydrants that failed, did the flow entirely cease, or only diminish to such an extent as to be noticeable?

MR. BRUSH. In the case of last spring, which I have clearly in mind, it dropped from 150 lb. to 50 lb. at the hydrant. In the case of 1918, while there was not a complete stoppage, there was a greater stoppage than occurred this spring. In both instances it was before April 10 that this difficulty occurred.

MR. MCINNES. Mr. Brush correctly stated that in Boston the Fire Department operates the stations, while the Public Works Department maintains the system. In Mr. Brush's case he has an excellent mechanical engineer equipment. We have nothing of the kind, and we are afraid of the combination. We are afraid of one fellow blaming the other, and we considered it would be safer and better to have everything in the hands of the Fire Department.

Now, in regard to the fire alarm. The Superintendent of the Fire Alarm fought hard and long, and succeeded in having it stipulated that all alarms should go first to headquarters and then to the station. His reason was, as I understand it, that particularly in the case of multiple fires there would be much greater danger of confusion and misunderstanding if orders were given by different men directly to the stations than if all orders came to headquarters, where a trained man would get them and would sift them out, sending only those that should be sent to the pumping station.

MR. BRUSH. There have been one or two instances where the Fire Department men have failed to coördinate among themselves in telling the stations what to do. Whether they will change sometime and have the orders sent to headquarters and then transmitted or not, I do not know. Where we are operating on two or more fires we have cut down the pressure when ordered to do so when the fire chief at the second fire might prefer to have it kept up. There have been two or three instances, where the Fire Department operating on one fire sent a certain order, and from another fire a different order has been sent. In New York the men telephone directly from the box to the pumping station as to what is to be done.

MR. MCINNES. That was the outstanding reason in our case why it was thought that everything should go to the trained man who could best say what should go to the stations. Another reason, which I neglected

to mention, was that we in Boston have a dislike of telephoning, on the possibility of easily misunderstanding a number of different words, letters and sounds over the telephone, so that we were opposed to the use of the telephone for that purpose and very much preferred the telegraph with the telephone only for verification.

MR. BRUSH. I do not recall any instance where there has been any misunderstanding from the telephoning of orders. Confusion has only resulted due to orders being given by two separate fire chiefs operating on two separate fires at the same time.

MR. HARRY A. BURNHAM.* The National Fire Protection Association has a committee on private fire services from public mains and among the topics which they are about to consider, is the fullest use of these high pressure fire services. As fire-fighting equipment they are comparatively new in the history of fire fighting, and I think at this time we should approach the subject with considerable caution.

It seems to me this might be a good time to find out what the real reasons are for not providing connections to automatic sprinklers from these. I think that in some cases it perhaps can't be done. But in others—anticipating Mr. McInnes' reply — it seems to us a matter of control pure and simple, and if a proper and safe method of control could be worked out it seems as if one of the difficulties might be in a fair way to be solved in allowing sprinkler connections to be taken from these systems. It is a new subject, and I would like to know if that is the only objection to providing sprinkler connections from high pressure systems.

MR. DAVIS. In Philadelphia, where we have a comparatively low normal pressure, the underwriters, the sprinkler people and a number of builders urged very strongly that connections be made to the high pressure for sprinkler purposes. The Water Bureau opposed it strongly and will object until we see some reason that has not been presented at the present time.

In the first place, we do not know of any check valve that will be perfectly safe against interior pressure when there is a pressure possibly up to 250 lb. or 300 lb. Such a check valve as would prevent bursting of the sprinkler heads of the piping we do not know about, and do not want to be responsible for damage by water, neither do we want to have the high pressure diminished in case of a fire, at a very critical time, possibly, from that use. Furthermore, we do not believe that it is safe to put the high pressure fire system under the individual control of private buildings. We know that there is a very strong tendency, not only on the part of responsible people, but on the part of irresponsible employees, to make surreptitious connection inside. We do not know yet of any way to control that.

The high pressure fire system, as Mr. McInnes has said, should be the gatling gun, the last resort against a very serious conflagration. It is meant for that. The fire fighters have the right to expect that their high pressure

* Engineer and Special Inspector Factory, Mutual Fire Insurance Co.

system will be absolutely dependable. They are risking their lives, and if they have the high pressure fire system and are working it, they should be absolutely assured that it is perfectly safe. When you introduce pressure inside of the buildings you are going to have places, as Mr. Mc Innes said, where you will lose water. If any city goes to the expense of putting in a high pressure fire system it should be for high pressure service, external alone, and that only, from the Water Bureau or the fire-fighting point of view.

But I believe that there may be a tendency to over extend the high pressure fire service. If we were firemen we would want the high pressure fire service extended to the utmost. We would want to feel that we had this great flood of water which could drown out any fire, if it was necessary. But, on the other hand, if that tendency is met and the high pressure system is extended unduly, there may be, in certain cases, a tendency to diminish and not put so much stress on the extension of the ordinary water system, possibly not so much stress laid on increasing the ordinary water pressures, and that may tend to minimize the sprinkler service that would be obtained from the ordinary water pressure. At the present time we should give due weight to the fact that these large automobile pumping engines that Mr. Booth mentioned as available, are much more flexible, much more easy to control than the old time fire engine, and instead of extending the high pressure service unduly beyond certain definitely defined lines the money could be more profitably expended, in many cases, in larger mains, larger hydrants, and a larger number of modern, powerful fire engines.

In regard to the sprinkler people in Philadelphia. Mr. Diven suggested that we do not maintain high pressure all the time, but we do maintain ordinary city pressure, so that the mains are charged. But the thought was to put in one or two smaller units, to keep up the pressure at the station at a relatively small cost, and then in case of fire to put on the larger pumps.

There is another factor in Philadelphia, which does not hold in many cases, and that is that one-half of the system is charged with raw water from the Delaware River, and the other half is filtered water. Of course there is considerable objection to putting raw water in the buildings where connections might be made.

I might mention one other thing, and that is about the relations between the Water Bureau and the Fire Department. In Philadelphia the Water Bureau operates and maintains the high pressure fire system, including the operation of the fire hydrants at the time of the fire. At each high pressure station there is stationed one fireman on duty all the time, these being generally men who are crippled or hurt at the fires, and who are stationed there until such time as they recuperate, or perhaps permanently, depending on the nature of the injury. In fact, he is the liaison officer between the Fire Department and the Water Department.

Every fire alarm is recorded at the pressure station, and if it comes within the zone the pressure is raised to the minimum limit, I believe 75 lb.

or 100 lb. Then the Water Bureau sends a crew of men, uniformed but under the control of the Water Bureau, to the fire, and they operate the fire hydrants, and the firemen take the water from those hydrants just as they do from the ordinary fire plugs. There are telephone fire boxes scattered through the high pressure system, and orders through these district boxes are transmitted to the firemen at the high pressure station by the man who has charge of the fire, and the pressure is raised or lowered according as requests come in from the Fire Department.

MR. BURNHAM. In reference to high pressure on the sprinkler system, it may be of interest to know that there are now several manufacturing plants where the sprinkler equipments have been under pressure of 175 lb. to 200 lb. for ten years or more. Of course that is an unusual condition. And no unfavorable experience has been met with those systems. As a matter of fact, the matter of mechanical strength can be taken care of if found necessary and advisable.

To raise the question again about the hydrant failures Mr. Brush mentioned, whether it was the practice in laying those high pressure pipes in Brooklyn to lay them as deep as the domestic service pipes? It occurred to me perhaps there being no circulation in those pipes, that they would be more apt to freeze.

MR. BRUSH. It was the intention to put these pipes deep enough so as to avoid trouble of that kind, but where we had sub-surface conditions which could not be overcome in any other way than by raising the high service mains, the high service mains have been raised, and there has been provision made for opening a number of connections so as to create a circulation in those locations where it seemed likely from the local conditions that there might be freezing. But we have had no instance where the pipe froze solidly and broke except at Brooklyn at one station. We have had the two hydrants where the flow was suddenly cut off by an unknown cause. That, however, represents a record of about seventeen years.

MR. BOOTH. I rather expected that this matter of automatic sprinkler connections would come up. We in the beginning approached the subject from the standpoint of the water works superintendent, because we are interested in municipal fire protection as a whole rather than in the protection of individual buildings. It is true that these systems were installed in practically all cases with the idea of giving the Fire Department the strongest weapon possible for use on outside fires. It is true also that in very few cases is the normal pressure carried sufficient to supply automatic sprinklers. San Francisco, if I remember rightly, is the only city that carried sufficient pressure. But I do think it is possible to so safeguard the connections as to make the automatic sprinkler practical and possible. I expect there will be come-backs on that.

I think Mr. McInnes, for instance, went too far in stating that the broken off connections at Salem, Chelsea and other places, were such a

serious handicap to the Fire Department. I think you should differentiate very strongly between the connection to an automatic sprinkler system and the connection for other purposes — for elevators, flushometer closets, and so on. The building with the sprinkler in it is so much safer, in the first place, than the ordinary building would be, that you are not running anything like the risk in putting your pipes in that building that you would if the pipe was for ordinary domestic or manufacturing purposes.

We have tried to find a record of as many cases as possible where connections to automatic sprinkler systems have been broken off and reduced the pressure unduly. There are very few of them. I wish you men would help all you can to get together cases of that kind. A great many references have been pretty indefinite. "A broken 6-in. connection in such-and-such a place in 1908 seriously reduced the water pressure." It is not very satisfactory when you get no more definite information than that. The Salem case, I will admit, was a marked one, where the automatic sprinkler supply failed to check the fire, the connections were broken off, and the system was bled very extensively. As a matter of fact, I do not know of any other such definite case where that happened, although there may have been other cases. In every conflagration that I know of there have been many broken connections of all sizes. Mr. McInnes, for instance, read the number and sizes of connections broken off in Baltimore during that conflagration. Although a great many of them were small they reduced the pressure very materially. In fact, that happens in any conflagration; your pressure will be reduced below the point at which you can use the Fire Department equipment with the normal degree of effectiveness. But even in cases like that of the Salem fire, there is in almost every case enough pressure left at the hydrant to give to the fire engine a fair amount of water — not as much as they could have used, but enough for one good stream from each engine. I think it is a subject that ought to be looked into further, particularly as to the differentiation between broken off connections to automatic sprinkler system and those for other purposes.

Mr. Davis suggested the point that if the way were opened to supply automatic sprinklers from these high pressure mains, they might become so numerous that it would be a very serious menace to the system. There is another angle to that, which is that I do not believe there is anything which would more greatly safeguard your city than a pretty general automatic sprinkler installation. Mr. Davis says it will very materially injure the system, but you have to look at it from the other point of view also, and if you get in enough sprinkler systems you will have a district without any great conflagration hazard.

MR. DIVEN. Isn't it best to have a system independent of all these other conditions? Is there anything to fight the fire with when the other system gives out? Is it a distinct advantage to have an independent system?

MR. BOOTH. I have not been able to satisfy myself that it is so much of an advantage as most of you think it is.

MR. DAVIS. Where do the sprinklers do the most good; in the basements or in the higher stories? I understand the great majority of fires start in the basements. In most every system there is pressure enough to give a fairly satisfactory sprinkler service in the basement. Wouldn't that be a good starting point for the sprinklers?

MR. BOOTH. That is entirely true. Of course any system will furnish a supply to a basement sprinkler. If you go that far you have gone a long way towards eliminating the fire hazard in the down town sections. The basement fires are most difficult to fight.

MR. MCINNES. I have to stand beside Mr. Davis with both feet. As an objector to connections from H.P.F. mains. But I want to be constructive as well. I can't clearly see how the ordinary high pressure fire system, in which there is effective pressure only at time of fire, can be effective with these little fires that start when the sprinkler must begin its work. Why cannot the same thing be obtained in a more effective way by providing means for such connection and making it the invariable and imperative practice of the Fire Department to make one of their first connections from the high pressure fire hydrant to the outside pipe, with check valve, supplying the sprinkler system? That has always seemed to me to be the sane way to get at it.

MR. BOOTH. There is a whole lot in that, but not all Fire Departments are as progressive as the one Mr. McInnes knows about. It is only within a few years that a few of the larger and more progressive Fire Departments have been willing to make it absolutely standard practice to connect the first line, or the second line from the first company, to your outside sprinkler connection. They are coming to do it more and more frequently. And if they would do it consistently and in all cases, you would get the second connection made in time to serve as an adequate secondary supply. That is one solution of the problem which has been suggested, and it is good as far as it goes.

MR. BRUSH. If I understood correctly, Mr. Booth suggested that the water works men get together on this matter of the connection with the high pressure system, with a view of working out some method whereby there might be additional connections allowed for sprinkler service. My suggestion would be that he keep the water works men as far apart as possible if he hopes to get that accomplished. Get them one by one and then sand-bag them. (Laughter.)

I know in New York an effort was made to have favorable consideration given to the question of making these connections. That was fought by the Water Department, and certainly until the Fire Department comes to the forefront on the proposition and says that it wishes to have these connections made, I am sure that no water works superintendent or engineer would take the responsibility of advocating connections which

are for the purpose of benefitting primarily the individual who owns the large building, or the building that requires the sprinkler system, whereas the high pressure system has been put in for the benefit of the community which includes a great many people who are not directly, and perhaps not indirectly interested in the fire protection of the one building. Of course we all appreciate that that one building may be the beginning of a fire which will cause a loss to the community, and if properly equipped with sprinklers that fire might never get headway in that building. But the individual can protect that building satisfactorily, and the community can, and usually does, furnish an adequate water supply outside of that building, which can be raised to sufficient pressure by the action of the owner of the building without endangering the continuity of the supply for the Fire Department from the high pressure system, which is distinctly a defensive system.

MR. BURNHAM. I will add a statement about Salem. I think it was definitely established that there was a very large flow of water that drew the pressure down, but I do not think it was quite as definitely established that it was caused by the breaking off of the sprinkler connections. We looked into the matter quite at length and found that the locations of the sprinklered and non-sprinklered buildings at the start of the fire were such that the heat from the burning building which was not sprinklered, could open sprinklers in several stories in the sprinklered building. And we came to the conclusion that enough sprinklers could have opened in that way to have caused the drop of pressure attributed to the broken main.

MR. MCINNES. The main did not break. The buildings were burned, and there were pipes broken within the buildings. It was broken inside equipment which caused the trouble.

PRESIDENT BARBOUR. When I wrote Mr. Booth to ask him to contribute a paper, I suggested that it would be well to include in his paper a statement of the result of reductions in rates, which have followed the installation of these high pressure service systems. He has side-stepped this phase of the situation entirely and apparently the thought that rate reductions might reasonably follow the provision of what is proclaimed by the insurance men and the fire chiefs to be the greatest fire-fighting instrument yet devised has not forcibly registered on his mental screen. The divorcing of the engineering division of insurance companies from the income department is certainly a most convenient arrangement.

I may be a foolish optimist, but it seems to me that it should be possible to get on our record a statement of the economic return — if any — in reduction rates, which has accrued or may be reasonably expected to accrue to those cities which undertake large expenditures for high pressure fire service. So far as now appears there has been no such reduction in rates.

High pressure fire systems have as yet only been installed in large cities. I take it that a certain minimum total area of a certain value will justify high pressure service and I am wondering whether or not such areas

are found in some of our smaller cities. I have had the thought that the installation of high pressure service in such cities might naturally affect the design of the general distribution system, and that in some cases the reduction in the cost of this latter system might in part offset the cost of the high pressure service. I therefore hope that Mr. Booth will give us some idea of the value per acre in the districts of the various cities where high pressure systems have been deemed necessary.

MR. BOOTH. That reminds me of one point I had in mind to discuss, which was the question of the type of city or district in which such a system might be warranted. Of course there is on the one hand a reduction of rates and a saving to the property owners. On the other hand, there is the possibility of saving to your city in the maintenance of its Fire Department. Your high pressure system can operate with fewer men, and perhaps with fewer companies. But your district must be of sufficient extent so that the companies located within that district won't have to cover any very considerable area outside of the district, otherwise you have to have the same number of men and the same equipment in pumping engines as you would without the high pressure.

Perhaps you will understand better what I mean if I say that in a district the size of this one in New Bedford, for instance, the down town companies on the first alarm, or at least on the second alarm, run from the mercantile or manufacturing section up into your residential district. Is that right, Captain?

CAPTAIN GIFFORD.* Yes.

MR. BOOTH. Every down town company has a run outside of the district here?

CAPTAIN GIFFORD. In this town, yes.

MR. BOOTH. So that your city must have a district of sufficient size to warrant the maintenance of companies in that district which have no or practically no runs outside. Otherwise, you have to have the same men and equipment as you would without a high pressure system.

I remember a few years ago the city of Hartford made quite an investigation to determine whether it was practicable to put in a high pressure system. They concluded that there would be little saving in Fire Department maintenance, on account of the fact that the district was comparatively small in Hartford. It would take about the same men and equipment.

MR. DAVIS. Does the National Board recommend the lowering of rates?

MR. BOOTH. We have nothing to do with that. We are supposed to keep our hands off. We do come in indirectly in this way: The National Board has a standard grading schedule which I think most of you know something about. It has been discussed in the meeting of your Association. In that schedule there is a provision for a removal of the points of

* Of the New Bedford Fire Department.

deficiency charged against bad construction conditions following the installation of the high pressure system. In Philadelphia, if I remember rightly, about half the points charged against bad structural conditions are removed because you have this powerful system. It is certain in that way to better the classification of your city.

MR. DAVIS. Do you, after investigation, ever furnish the water works officials with the rating of their cities?

MR. BOOTH. Yes, sir. On request.

MR. DAVIS. Will you furnish it?

MR. BOOTH. I will be glad to.

MR. DAVID A. HEFFERNAN.* Hasn't the cost of maintenance of the Fire Department been increased greatly with the two platoon system? Have you any idea what the percentage of the increase is?

MR. BOOTH. I suppose it has doubled up in a good many cases.

MR. HEFFERNAN. You said there was a saving to the cities with the high pressure system. With the two platoon system it would be the other way, wouldn't it?

MR. BOOTH. I mean, it has decreased the cost of maintenance, because with the high pressure system you can run your department with fewer men and less expensive equipment. It is true that cities that have gone on the two platoon basis add on an average a third to the number of men. Your salaries have gone up, so that in a good many cases the total expense has doubled. We used to think that about two dollars or two dollars and one-half per capita meant a pretty good Fire Department, but now a good many of them run over four dollars, and some five or six dollars per capita.

MR. DIVEN. One of the advantages, to my mind, of the high service system, is the possibility of a better sanitary supply for the city — a better general domestic supply. For instance, there might be a limited domestic supply, not sufficient for fire protection and the domestic supply, of an excellent quality of water which could be used if the same mains and the same system did not have to also supply the fire protection. This is, of course, meant particularly where the high service fire protection can be taken from an entirely different source. Most any water is good enough to put out fire; in fact, I have heard firemen say that the impure water was a little better than the filtered water for fires.

It seems to me that there might be many cases where that would be a very decided advantage to the city, and if the two systems could be designed together there would be a very great saving, perhaps, in the construction of the general or domestic supply system, as smaller mains could be used. You would not have to provide mains that would furnish a large quantity of water at a given part of the city at any time, when mains supplying much less than that quantity would answer all of the domestic purposes. A very decided advantage is the possibility in some cases of

* Superintendent Water Works, Milton, Mass.

securing a supply which is good in every respect, and an entirely separate supply for fire protection.

PRESIDENT BARBOUR. Mr. Booth, do you think it would be possible for us to get any statistics showing the average valuation of the districts that are protected by high pressure systems? If there are in some of the several departments of the insurance world, which are so carefully separated, such statistics in existence, and whether they are following the installation of these high pressure services by reducing the rates?

MR. BOOTH. It would be pretty difficult, from what I know of the statistics available, to determine what the values involved in the districts are. I will try to get it.

PRESIDENT BARBOUR. I think that will be a very interesting basis for future consideration of the ordinary engineer who approaches this problem, if it can be gotten.

MR. BOOTH. Jacksonville, Florida, is a good example of the smaller city that has been able to afford a system of this kind. That is largely because they operate a municipal lighting plant and get their power very cheaply. They were able to put up a pumping station on city owned land.

MR. DIVEN. They use river water entirely, do they not?

MR. BOOTH. Yes.

MR. DIVEN. They are satisfied with very little.

MR. BOOTH. In answer to your point made a little while ago, the total amount of water used on fires is a very small proportion of the total amount used for domestic purposes.

MR. DIVEN. Yes; but it comes in big chunks.

MR. BOOTH. Yes; but you almost always have mains large enough to supply the big chunks.

MR. DIVEN. You would not necessarily have those if you had other mains to supply the fire protection.

MR. BOOTH. In most cases they are already in. You have to have them until your high pressure system, if you put one in, protects the district in which your high pressure is necessary.

MR. DIVEN. How about your filter plants? They would have to be larger if you used a filtered supply.

MR. BOOTH. There are almost always areas outside of the system which demand about as much water as the mercantile district.

MR. DIVEN. Not ordinarily. The high pressure ordinarily covers the congested district.

MR. BOOTH. Yes; but there are almost always sections outside which demand about as much water. It has not ordinarily proved to be any material saving to the Water Department to attempt to use a second supply.

MR. LINCOLN VAN GILDER.* Referring to the question of reduction of rates due to the high pressure system, I can't give you figures directly from memory, although I think they can be obtained from the Rating

* Superintendent Water Works, Atlantic City, N. J.

Bureau of the city. But I do know that Atlantic City recently got a 12 per cent. reduction in rates, due to better fire protection, or a better fire-fighting system; a better volume of water available for the city and also the high pressure. And this is in spite of the fact that the high pressure system has not yet been formally approved and that the rate was raised in every other city in the state. On the Board Walk, where the values are high, and where the class of buildings and the contents are very inflammable, the insurance rates in the past have been very high, but since the installation of the high pressure system the Rating Bureau has made a substantial reduction to those buildings on the Board Walk that are adjacent to the high pressure system, because of the high pressure supply, and before its formal approval.

There is another thing. The engine rooms are all supplied with an alarm, so that the alarm is struck through all the engine rooms at the same time it strikes on the general switch board in the Fire Department and Electrical Bureau, and they respond at once by giving 125 lb. pressure until further orders. The engine rooms are required to respond if the fire is within one block of the high pressure system.

On one occasion I recall a fire two blocks away on the Board Walk from the nearest plug — 850 ft. by actual measurement. The chief of the department made connection and got an effective fire-fighting stream.

PRESIDENT BARBOUR. There is another phase that has not been developed as fully as I think it might. Mr. McInnes has stated that only in one fire in Boston has more than 125 lb. at the pumps been called for.

MR. MCINNES. Ten per cent. of the fires.

PRESIDENT BARBOUR. I think that in Boston as yet, not more than 125 lb. has been called for.

MR. MCINNES. Not yet.

PRESIDENT BARBOUR. I am wondering whether there is any justification for the 300 lb. pressure, particularly in the smaller sized installations. I would like to ask Mr. Booth if he has an opinion to express on this question of pressure. It seems to me that the quantity of water at a certain minimum pressure is the controlling factor.

MR. BOOTH. That 300 lb. pressure I think was a figure that was assumed in the case of New York — not by the underwriters but by the city authorities themselves. I do not believe myself that there is any justification for such a high pressure. It has never been used in New York or anywhere else. I do not think we will ever have any more severe try-out of any of these systems than has already been had in two or more instances in New York.

PRESIDENT BARBOUR. Of course that must have a very direct influence on the cost of installation.

MR. BOOTH. Not so much so as you might think. Has it, Mr. McInnes?

Mr. McInnes. It is almost entirely in the thickness of the pipe. I agree with Mr. Booth entirely. So far as our city is concerned, 150 lb. is sufficient. But the increase in cost would not be so great as would appear at first thought. On the pumping station it would be very slight. There would be an increase in the strength of the walls of the pipe.

President Barbour. The increase in cost may not be so affected, but the risk is materially reduced by lighter pressure. Take the Boston situation. The regulators maintain a certain pressure beyond the pumps, but 300 lb. is always on the pumps in time of fire.

Mr. McInnes. That is right.

Mr. Booth. Of course you have to figure on some lines a good deal longer than others. In the case of a big fire, where you are using a good many hydrants, some lines will be 800 ft. or 1 000 ft. long. You have to figure on 90 lb. or 100 lb. at least at the nozzle. That means, with a line 800 ft. or 1 000 ft. long, with 3-in. hose, that you would have to have something more than 150 lb. at the hydrant. I think perhaps 200 lb. or 225 lb. is a fair maximum to expect that you might need.

Mr. Diven. Can you give us some data between the pump pressure and the pressure at the end? I think Mr. Brush may be able to give us something on that, because they have probably longer lines of fire pressure mains than any other city.

Mr. Booth. If I remember rightly, the New York system was designed to deliver 20 000 gal. per min. about any one block, with a loss in pressure not to exceed 40 lb. It will do better than that, I believe. What figures did you assume, Mr. McInnes?

Mr. McInnes. We assumed a loss of 50 lb., 12 000 gal. per min. in any block, pump pressure of 300 lb.

Mr. Davis. The pipe diameters which you gave — are they nominal or actual, inside or outside?

Mr. McInnes. They are actual pipe diameters.

Mr. Davis. You do not have the uniform outside diameter?

Mr. McInnes. No. Personally I question the wisdom of excessive thickness of pipe walls, as they have been made in many cases.

Mr. William R. Conard.* Regarding excessive thickness of pipe walls, in cast-iron pipe, which is the principal material used in high pressure fire systems; the strength of the metal is dependent on the inner and outer skin of the pipe, and the thicker the section of the pipe the more open and weaker the inner section; if you can grasp what I am trying to explain. To put it from the standpoint of metallurgy, as you increase your thickness the percentage of carbon in uncombined form in the inner section of the pipe wall, increases. That can be partially overcome by a change in your mixture, but there are in mixture changes, points beyond which you cannot go and expect to maintain your strength.

* Inspection Engineer, Burlington, N. J.

On the question of the pressures for the high pressure fire system it would appear to me that probably the 300 lb. was arrived at as a factor of safety, and the jump in thickness of walls from the class of pipe which would be used for maintaining a working pressure of, say, 125 lb. to 300 lb., is about 33 per cent., and that is reflected in the cost of the pipe in the system alone. The increase in proportions would not be so great in the other parts of the structure in a high pressure system, as I view it.

PRESIDENT BARBOUR. I note that Mr. Conard says that 300 lb. pressure is adopted as a factor of safety and, undoubtedly, a reasonable factor of safety is always necessary. But what about connecting sprinkler systems to these high pressure services? Surely this reduces the factor of safety in another direction, and if such connection is debatable, then the question of the necessary pressure is certainly relevant. It is a surprise to me to have Mr. Booth apparently favor this connection of sprinkler systems. My thought has been that an independent high pressure fire service is justifiable only as a means of external fire fighting, and because such a system provides a weapon free from all such disturbances as may result from any connection other than those under the control of the firemen.

MR. MCINNES. I think you are entirely right there. We consider it an extra insurance. When I look back at our calculations that is very clear to me. The pipe sizes used in Boston and New York are practically Class " H " H.P. Service A.W.W. While our figures call for lighter pipe, and it would be wise before large future installations are made to at least make an actual test to the breaking point of the lighter pipes before adopting the heavier type; apart from economy by reason of weight the lighter section makes more certain a uniform texture in the metal.

MR. DIVEN. To come back to the sprinkler system again. Sprinklers are supposed to put out fires with very small quantities of water, and certainly the domestic system will supply that much if they are connected with it. As I understand it, the high pressure systems between fires have only the ordinary domestic pressure, by a connection with the mains. Is that right? Between alarms you carry the same pressure on your high service that you do on the other?

MR. DAVIS. Yes.

MR. DIVEN. So that the sprinklers would be no more effective before the alarm was sounded and the pressure increased than they would be if connected with the domestic system, and as for the excessive use of your domestic system running the pressure down, it runs it down on the fire alarm just the same. I can see from that absolutely no advantage to the sprinkler system to be connected with the fire system, and a distinct disadvantage to the fire system by being connected and taking the risk of having a large waste of water by breaking the system by undue pressure in the sprinkler heads.

MR. FRANK E. WINSOR.* Mr. Diven's last remark brought to my mind the fact that in Providence the condition that he has explained to you is not so. We have two systems of water supply there, two systems of pressure — a low pressure and a high pressure. The low pressure supplies water up to an elevation of about ninety ft. and the high pressure supplies that part of the city higher than 90 ft. In addition to that, the high pressure is connected into a high pressure fire district, generally in the low level part of the city, and those pipes, which it is true are connected into the same mains that supply domestic consumption in the high level district, have no connections in the low districts. In other words, buildings in the low service district which are too high to be supplied directly on the upper floors from the the low service, are not permitted to make any connection on the high service fire system for domestic use. Neither are there any sprinklers on the high pressure fire system.

MR. CONARD. That, as I understand the condition which Mr. Winsor has just described, is also true of the city of Newark, New Jersey, except that Newark has a gravity supply, and the high pressure system in the down town section gets its pressure from the high level system.

Perhaps Mr. Booth can tell us whether the sprinkler systems in the down town districts of Newark are connected with the high pressure system or the low pressure system.

MR. BOOTH. They are all connected with the high pressure system.

MR. WINSOR. Perhaps I did not bring out that the low pressure system in Providence is also a gravity system, supplied by a reservoir. There is no pumping, other than to the distributing reservoir.

* Chief Engineer, Providence Water Supply Board.

ELECTRIC PUMPING AT CONCORD, N. H.

BY P. R. SANDERS.*

(*September 15, 1922.*)

The water supply of Concord, N. H. is obtained from Penacook Lake, which is two and one-half miles long and one-half mile wide, located about three miles from the center of the city.

The overflow is at an elevation of 125 ft. above the business section of the city. From 1872 when the system was installed until 1892, the total supply was furnished by gravity alone.

As the growth of the residential section extended westward into the higher parts of the city, it became apparent that steps must be taken to provide an increased pressure. In order to secure this increased pressure, in 1892 a high service system was installed consisting of a 2 000 000-gal. reservoir at an elevation of 200 ft. and a 2 000 000-gal. Worthington triple expansion pump.

In addition to using this high service supply for the higher section of the city, a 20-in. main was laid through Main Street for fire protection only, directly connected to this system, and this has later been extended to other business sections.

The pumping station is located between the city and the lake, on the main pipe line, about one mile from the center of the city and two miles from the lake and is supplied by gravity at static pressure of 50 lbs., from an 18-in. cement-lined main and a 20-in. cast-iron main which also furnish the gravity supply for the city.

In 1904 when the village of Penacook, a part of the city six miles north, was added to the high service, a second Worthington triple expansion pump was installed. Up to this time the daily average amount of water pumped was 400 000 gal.; after the addition of Penacook, it increased to 800 000 gal. The total daily consumption for all purposes is nearly 2 400 000 gal., 800 000 gal. from the high service and 1 600 000 gal. from the gravity service.

In 1917 when the United States entered the war and coal was needed for the manufacture of munitions and other war supplies, it seemed best after a thorough investigation of the matter, to release the quantity of coal used to run our plant and pump by electricity.

In this respect Concord is very favorably located, for power is manufactured by the Concord Electric Co., at their plant at Sewall's Falls, and the line is also tied in with the Manchester Traction Co. at Garvin's Falls, both of these plants being located on the Merrimack River.

* Superintendent of Water Works, Concord, N. H.

A rate was made by the Concord Electric Co. to the Water Works, by which they were to furnish us power at 1½c. per K.W.H. After we had paid $1 800 there was to be no further charge until we had pumped 300 000 000 gal. and then the rate was to be $6 per million gallons pumped, figured on a yearly basis. All pumping was to be done at night between the hours of 8 P.M. and 6 A.M. except in times of fire or other emergency when we could pump as required.

A contract was made with the Worthington Pump and Machinery Corporation for an 8-in. single stage, horizontal, split case, double suction, volute pump, to have an efficiency of 72 per cent. when pumping 2 100 gal. per minute or 3 000 000 gal. per 24 hours, against a net operating head of 120 ft.

To drive this pump, we furnished an A.C. 100 H.P. General Electric motor of the squirrel cage type, to operate at a speed of 1,800 R.P.M., which was guaranteed by the makers to have an efficiency of 91.5 per cent. when operated at either full or three-quarters load. A 20 x 8 Venturi meter was placed on the discharge main. This pump was placed in service in August 1919.

As the water is taken directly from the mains that supply the city, provision had to be made to take care of the water hammer caused by the shutting down of the pump and a 4-in. relief valve was placed on the suction to discharge into the sewer set at an overload of 20 per cent. The pump operates against a check valve on the discharge side as it is not necessary to start against a closed gate.

No addition or new building was necessary as there was ample room in the existing engine room.

The steam pumps are kept for emergency and the fireman is released for other duties. A small heating apparatus was installed to heat the engine room, as it was considered too expensive to use the large steam boilers for that purpose.

A test of the pump was made for the month of September 1919, with a daily average of 654 333 gallons pumped, 340 K.W.H. used and a net head pumped against of 126.4, and the pump showed an efficiency of 85.18 per cent.

During the year 1920, the record of the electric pump by Venturi meter measurement was:

Water pumped, 308 879 000 gal.
Daily average pumped, 843 931 gal.
Gallons pumped per minute, 2 640 or 3 800 000 per 24 hours.
Total K.W.H. used, 156 610.
K.W.H. per 1 000 000 gal., 506.
Static head, suction, 50 lbs.
Static head, discharge, 88 lbs.
Dynamic head, suction, 37 lbs.
Dynamic head, discharge, 90 lbs.
Net head pumped against, 122 ft.

With switch board loss of 2 per cent. and motor efficiency of 91.5 per cent. this gives an efficiency of 84.25 per cent. The record for 1921 was equally good.

The cost of installation was as follows:

Centrifugal pump, foundations and fittings,	$2 415.22
Motor and switchboard,	1 291.50
Venturi meter,	1 406.16
Heating apparatus,	344.78
Total cost,	$5 457.66

The supplies used for the past year were 14 gal. of oil, 47 lb. of packing, 74 lb. of waste and approximately 12 tons of coal to heat the building.

The cost of pumping by steam figured on total pumping station expenses with no allowance for interest or depreciation charges was:

Year	Per Million Gal.	Year.	Per Million Gal.
1911	$11.65	1916	$15.40
1912	12.34	1917	16.22
*1913	19.49	1918	17.06
1914	13.12	†1919	15.14
1915	14.03		

*Excessive repairs. †Steam and electricity.

Cost by electricity,

1920	$13.16 per million gal.
1921	12.90 per million gal.

As wages and supplies were at least 33 per cent. higher in 1920–21 than in 1918, it is fair to assume that the cost per 1 000 000 gal. pumped in those two years would have been $22.70, pumping by steam.

The total pumpage for 1920 and 1921 was 578 737 000 gal. which, if figured on the above basis, would present a saving of $5 590 by the change to electric power; and in addition there is the advantage of the increased speed with which the pump can be started in case of fire.

Discussion.

Mr. J. M. Diven.* How much of those costs were labor?

Mr. Sanders. I should say one third.

Mr. Diven. Of course you save in labor on the electric pump very largely.

Mr. Sanders. Yes. We save the cost of the fireman and handling of the fuel.

President Barbour. Did you consider automatic operation or did you keep the same number of engineers on the electric pumps?

Mr. Sanders. We kept the same engineer. No, we did not consider automatic operation at all. We did not feel it was safe to do it.

* Superintendent, American Water Works Association.

MR. DIVEN. You were wise.

MR. SANDERS. And in addition to that, we pump at night, and the engineer has to ring up the police station hourly so as to make sure that nothing has happened and that the pump is not running without attendance.

MR. DIVEN. It would seem to me that the peak of the load on the electric light plant would come in the night time, and that they would want you to take the day load.

MR. SANDERS. It does not in our town, because there are a great many granite manufacturers there, and their light load comes at night. Of course all that is required is to turn the Merrimac River through another generator.

PRESIDENT BARBOUR. Have you had any outages? Have you lost current? Did you have the ice storm that we had last November?

MR. SANDERS. No; the shut down has been practically nothing by electric troubles. We had a little motor trouble that caused a shut down.

MR. DIVEN. Have you had any experience with automatic control?

MR. SANDERS. Never in water pumping.

MR. DIVEN. I had experience in a small plant where they changed from steam to electricity intending to have it entirely automatic. A message came that this little suburban town was out of water. The power had been switched on about two miles from the pumping station. We found a pile of wreckage in the pumping station. The pump was absolutely to pieces.

MR. HERBERT C. CROWELL.* Do you depend upon the electric pump entirely for pumping, or do you have some other power?

MR. SANDERS. We keep the original steam pumps there, in good operating condition, so that they are ready to start on short notice.

MR. CROWELL. What is the length of the transmission line?

MR. SANDERS. Three or four miles.

PRESIDENT BARBOUR. Have you a double transmission line?

MR. SANDERS. No; but the Sewall Falls, owned by the Concord Electric Company, is north of the city, and the Garvins Falls is south of the city, so that we can have it coming both ways. They are also tied in at Manchester with the plant there.

MR. CROWELL. Do you have to pay a fixed charge for the current? Do you have to guarantee to pump so much water?

MR. SANDERS. No, we do not. We pay $1\frac{1}{2}$ cents a kilowatt hour for all the power we use. That rate is figured on a basis of pumping 300 000 000 gal. of water a year. The maximum charge is $1 800. After paying $1 800 we do not pay any more until we pump 300 000 000 gal. of water, and after pumping 300 000 000 gal. the rate is $6 a million gal. It figures out approximately $6.40, but varies, of course, with the amount pumped.

MR. EDMUND DUNN. I am from Garfield, N. J. The first of January, we took over a steam-driven plant, with triple expansion Worthington

* Superintendent, Water Works, Haverhill, Mass.

pumps, similar to what they have in New Bedford, only horizontal instead of vertical. It was costing them $1.46 per thousand cu. ft. for pumping water out of deep wells. We installed an electric outfit and it is costing to-day 92 cents a thousand cu. ft.

MR. DIVEN. How large a plant?

MR. DUNN. About 2 000 gal.

MR. DIVEN. How much are you saving on labor?

MR. DUNN. Approximately $8 000 per year. We had three engineers and three firemen, paying 70 cents an hour to the engineers and 65 cents an hour to the firemen. We took them off. There are two men in the plant at the present time who are paid $100 a month. We have our Chief Engineer in case we have to start up an auxiliary steam plant.

MR. DIVEN. How much are you pumping per day?

MR. DUNN. We are pumping now 1 000 gal. a minute, running twenty four hours every day. We are getting the current at 1.17 cents per kw. hr. A guarantee is required to take 3 000 kw. hr. a month to get that rate but the use is unlimited.

MR. SANDERS. How is your power manufactured?

MR. DUNN. It comes from the public service generated by steam power. The water is lifted out of the wells to a reservoir by an air lift system of about a half million gal. capacity. Pumps are the twin Valute type, made in Newark. I was quite surprised to hear Mr. Taylor say that the pump in New Bedford was only about 60 per cent. efficient. We get 70 per cent. efficiency. That is not a Valute pump in the strict sense of the word, but a centrifugal. A Valute pump is made on different lines and gives greater efficiency. We have one plant electrified, and later will electrify the other.

MR. DIVEN. In the small plants the labor cost per million gal. is very high. I should like to hear from somebody who has a pump of ten, fifteen or twenty million gal. a day.

MR. DUNN. I can tell you about paper manufacturers I am working with who have gas and steam power. They have the Corliss type of engine of about 3 000 h.p. But steam power to-day is no use without fuel oil or coal. We are installing public service through the whole mill. There is nothing to depend on whatsoever in that plant with the exception of one unit to keep our fire system in order, which we are compelled to maintain to meet the requirements of the fire insurance companies. We figure out a saving of about $30 000 a year by using the public service in labor alone. And then you haven't any coal to bother with. The coal question is not worrying you much over here, but we are sweating for coal at the present time. We expect to close some plants, and there are a number now closed for the want of coal. The Public Service Companies have the advantage of us because they get their coal direct from tide water, and don't have to bring it in by automobile truck or rail, as their plants are situated at tide water and they send the current over the Empire State with high pressure lines.

APPLICATION OF COPPER SULPHATE TO HARTFORD RESERVOIRS AND SOME EFFECTS UPON LENGTH OF FILTER RUNS.

BY J. E. GARRATT.*

For several years copper sulphate has been applied to the various reservoirs of the Hartford water system at certain seasons of the year when the numbers of micro-organism have become large. Previous to the filtration of the supply, which began late in the fall of 1921, the application of copper sulphate to the reservoirs was principally for the purpose of improving the taste and odor of the water. Since the introduction of filtration, the application of copper sulphate has continued for the purpose of lessening the amount of material which the filters have to remove from the water, and thereby lengthening filter runs and reducing costs of operation.

Copper sulphate is applied to the several relatively small old reservoirs of Hartford's supply by traveling over the reservoir surface in a small boat equipped with an out-board motor, with a bag of copper sulphate crystals suspended over the side of the boat and in the water. A course around the reservoir starting close to the shore and gradually working out to the center is pursued. The course is determined wholly by experience and judgment. If the desired amount of copper sulphate has not been dissolved by the time the center of the reservoir is reached, such a random course is continued as will spread the remaining copper sulphate through the whole reservoir.

With the new large Nepaug Reservoir recently added to Hartford's supply the application of copper sulphate is a much bigger proposition, as it is a question of dissolving two tons or so each time. Here an eighteen foot motor boat is available. By experiment it was found that, with two bags of copper sulphate held in the water, one from either side of the boat near the stern, the boat would travel at the rate of about 6 miles per hour and 50 lb. of coarse granular copper sulphate per bag, or 100 lb. from the two bags, would dissolve in 5 minutes, using coarse mesh grain bags.

With this information as a basis it is possible to lay out courses over any portion of the reservoir which it is desired to treat so that the required amount of chemical can be dissolved in a more or less uniform manner. This ordinarily gives courses about 100 ft. apart. The dissolved sulphate is considerably dispersed by the churning of the propeller of the boat, which is one of the decided advantages of a motorboat.

* Office Engineer, Board of Water Commissioners, City of Hartford.

The Nepaug Reservoir is formed by damming two streams. There are, therefore, two more or less distinct basins to the reservoir. The outlet from the reservoir to the pipe line to the filter plant is located in one of these basins, and an attempt is made to keep this portion of the reservoir low in micro-organisms.

This basin has a capacity of about 1 800 000 000 gal., is about 3 800 ft. long, and has an average width of about 1 800 ft. It was first treated on June 17,1921, when total micro-organisms at the surface numbered 1 300 (principally *Asterionella* 750 and *Cyclotella* 500) and at a depth of 30 ft. numbered 350 (*Asterionella* 200 and *Cyclotella* 100). It was decided to treat at the rate of 1.5 lb. per million gal., which required 2 700 lbs. of copper sulphate for the 1 800 000 000 gal. in the basin. To dissolve these 2 700 lb., using two bags from the motor boat, required 27x5 minutes, or 2 hours and 15 minutes. During this time at a speed of 6 miles per hour the boat would travel about 13½ miles or about 72 000 ft. The average width of the basin being 1 800 ft. it is seen that 40 trips across would be required; and since the length of the basin is about 4 000 ft. the courses would be 100 ft. apart. These courses were laid out on a plan, and land marks only were used as guides when the courses were traversed. The motor-boat carried twelve 50 lbs. bags of sulphate besides a crew of three men, one to guide the boat and two to dissolve the copper sulphate. Since the rate at which the sulphate dissolved was much more rapid when the 50 lb. bag was first immersed, a more uniform rate of dissolution was obtained by putting a new full bag overboard on one side of the boat at the time that the bag already overboard on the other side was about one-half dissolved. No attempt was made by the men handling the copper sulphate to dissolve the last handful or two. When this stage was reached he passed the bag forward to the man steering the boat, who dissolved the small remaining amount while the main operation continued. It took a little over three hours to apply the 2 700 lb., two hours and fifteen minutes of which was actual time on the course and the remainder was time used in returning for other boat loads of sulphate.

Water samples taken at two widely separated points on June 21, four days after treatment, showed that the total number of micro-organisms at the surface had been reduced to about 300 (*Asterionella* 150 and *Cyclotella* 130). Some few small fish were killed by the treatment. About six pailfuls were picked up along the shore.

At this same time several smaller coves and portions of the reservoir, so located as to be conspicuous from the highway, were treated with equally successful results. The previous year a green algae scum formed in certain of these coves. None occurred during 1921 after the copper sulphate was applied. The micro-organisms remained low in number throughout the remainder of the year.

The new filtration plant was started in a small way during November, 1921. Only part of the total supply was filtered. Permanent rate of flow

and loss of head gages were not yet installed and only a temporary sand washing outfit was available. Piping is so arranged that water can be taken either from the Nepaug Reservoir, from the old West Hartford reservoirs, or from both sources at the same time. The water to the filters was taken first from the big Nepaug Reservoir. The number of filter units in use was gradually increased until early in February, 1922, the whole supply to the city was being filtered. Nepaug water was used until the middle of March. During all of this time the micro-organisms, which were very low in number, totaled about 50 (maximum 80 and minimum 25). The average amount of water passed between scrapings or rakings was about 125 000 000 gal. per ½-acre bed.

From March 17 to April 3, while high colored bottom water was wasted from the Nepaug Reservoir previous to the spring turn-over, water to the filters was taken from the West Hartford reservoirs. This raw water had a color of about 25. The numbers of micro-organisms were not as low as in the Nepaug water but they were relatively low; 80 on March 17 and increasing to 185 by April 3. A filtered water with color of about 15 was obtained, and the rate of clogging during this short period indicated that the quantity of water filtered between cleanings or rakings would have averaged about 100 000 000 gal. per ½-acre bed, had water of this character continued through the filters.

Nepaug water was again put onto the filter beginning April 3. By the end of the month micro-organisms had increased to 150 or so, more than one-half being *Asterionella*. In anticipation of the probable need of treating the Nepaug Reservoir with copper sulphate as was done the previous year, the principal West Hartford reservoirs in which the total micro-organisms had gradually increased to from 240 to 300 (in two *Asterionella* was the principal micro-organism and in another *Nitzschia*) were treated with copper sulphate at the rate of 2.3 lb. per million gallons early in the month of May in order to have them available with water low in micro-organisms for use while the big reservoir was being treated.

Early in May, with Nepaug water, filters clogged very rapidly. Runs of as little as 40 - 45 million gallons per ½-acre bed were the rule. It began to look as if night shifts would be needed on the washing outfit. On May 22 Nepaug water was shut off so that the reservoir could be copper sulphated. While the total number of micro-organisms did not seem large, yet there were several times as many as in the water which had been used previously. At the surface they totaled 300 and at the depth of 30 ft., 200. It was decided to treat the portion of the Nepaug Reservoir near the intake, that is, the same portion as was treated the previous year. Twenty-four hundred (2 400) pounds of copper sulphate were applied on May 23 in the same manner as during the previous year except that fine mesh burlap bags were used so that no fine grains of sulphate could escape. This was at the rate of about 1.3 lb. per million gallons of water treated, as compared with 1.5 lb. per million gallons the previous year. The predominating micro-organisms

were *Uroglena* 50 per cent. and *Asterionella* 30 per cent. The treatment, however, was without material results. Total organisms at the surface were not reduced in number while at the depth of 30 ft. they increased very materially to about 600 total.

In the meantime, the treated West Hartford reservoir water with total micro-organisms of 50 to 100 was put onto the filters, filter runs lengthened appreciably to 65 or 75 000 000 gal. between washings, and the washing emergency was passed.

But it was desired to use Nepaug water as soon as possible so it was decided to treat the same portion of this reservoir again and at a rate of about 2.5 lb. per million gallons. On June 3, 1922, four thousand (4 000) pounds of copper sulphate, all of which was on hand at that time, were applied. This was at the rate of 2.3 lb. per million gallons. Total micro-organisms were 250 at the surface and 600 at a depth of 30 ft., half *Asterionella* and half *Uroglena*. Quite a few small fish were killed. Samples taken three days after treatment showed slight reduction in *Asterionella* and practically no reduction in the number of *Uroglena*. Samples taken the following day, June 8, showed still further reduction in the micro-organisms at the surface (average total 140), but large increase in number at a depth of 30 ft. (average total 1 030).

On June 9 the change back to the Nepaug water was made, taking water from the intake nearest the surface where the micro-organisms were the lowest in number. On June 14 conditions were the same as on June 8, but by June 21 surface counts had decreased to an average of 65 and at the 30 ft. depth to an average of 100.

As a result of more or less off hand consideration of all this, it appeared that all that was necessary to do in order to keep filter runs long was to keep micro-organisms low in number. Careful watch, therefore, was kept of micro-organisms. No considerable increase was noticed in the Nepaug water, but all of a sudden, early in July, filter runs of 18, 20, 21, 23, 25 million gallons were gotten. Experience had shown that filters could be lightly raked over once or even twice without materially increasing the amount of sand to be scraped off and washed ultimately, so that no washing crisis seemed at hand, but on several beds there were periods of only ten (10) days between rakings or scrapings and in one case only seven (7) days.

While water in the Nepaug reservoir was low in micro-organisms it was found that water in the West Hartford reservoirs, into which the pipe line from Nepaug emptied, had developed a considerable growth of micro-organisms (*Nitzschia*), so on June 8 this reservoir (Reservoir No. 5 so-called) was shut off and the Nepaug water allowed to pass directly to the filters. Reservoir No. 5 normally is used like a surge tank to take care of the excess or to supply the deficit of Nepaug water, over or under the amount passing through the filter at any time.

About July 11 Reservoir No. 5 was treated with 2.3 lb. of copper sulphate, per million gallons the micro-organisms reduced from 270 to about 100 by July 18 and on that day the gate on the line to and from the treated Reservoir No. 5 was opened again. At the time this treated water was again free to pass onto the filters, one ½-acre bed had only passed 30 000 000 gal. of water and had lost three (3) of its five (5) ft. of head. Other beds had either just started on new runs or were practically at the end of runs of 20 to 25 million gallons as stated above.

A few days later it was noticed that loss of head on the bed which was in the midst of a run, Bed 3 so-called, began to decrease. It continued to decrease. At the same time a slimy deposit on the walls and bottom of the walls and bottom of the aerator disappeared. Bed 3 gained a new lease of life and continued in service until August 24, passing 90 000 000 gal. of water. Runs on other filters since the last of July have varied from 45 to 80. Micro-organisms in Nepaug reservoir have continued low, 30 to 50. But at the present time, August 25, micro-organisms in Reservoir No. 5 have again increased to over 300 without as yet causing any noticeable increase in the rate of clogging of the filters.

Presumedly we have not as yet gotten the whole story in regard to the amount of copper sulphate needed for effective treatment or in regard to the relation between number of micro-organisms and lengths of filter runs; but it is thought from the information so far collected that the application of copper sulphate has possibilities as an aid to economical filter operation with Hartford's water.

Discussion.

Mr. Garrett. In the matter of the application of copper sulphate to the reservoir, we have always been very careful not to put so much in as to kill the fish.

Mr. J. M. Diven.* On the matter of killing fish my observation has been that the game fish are seldom killed, — but it is such fish as carp, for instance. At the Troy Reservoir we took out six tons of carp. They are a mud fish, and work around in the bottom. The water being a little turbid, the copper sulphate was carried to the bottom and the fish got it. In all that six tons I think there was only one black bass that was killed.

* Secretary American Water Works Association.

WATER SUPPLY OF SOUTHEASTERN MASSACHUSETTS.

BY X. H. GOODNOUGH.*

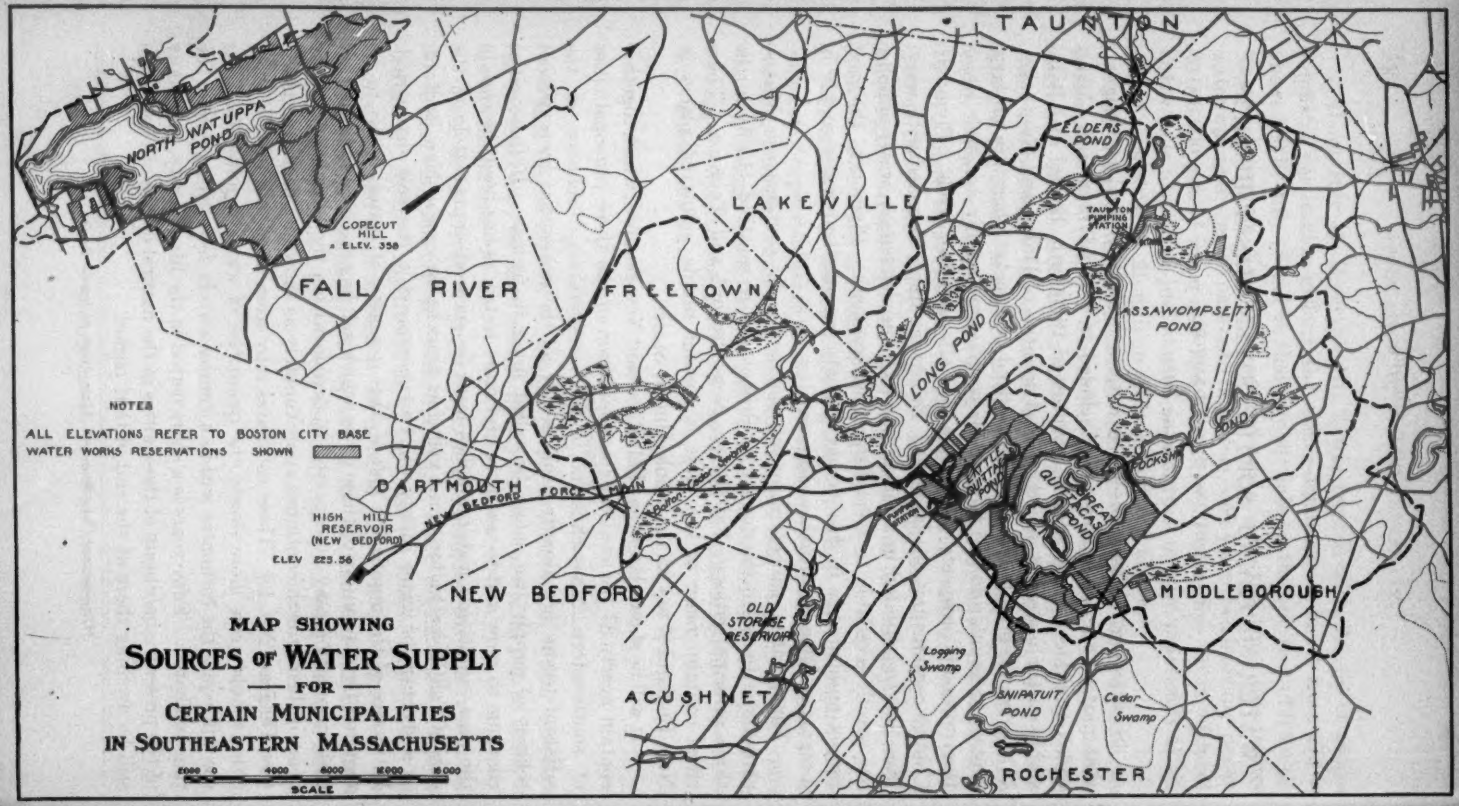
[*September–1922.*]

Southeastern Massachusetts is a term ordinarily used to designate that part of the Commonwealth included in the old Plymouth Colony which at present comprises the counties of Plymouth, Bristol and Barnstable on the mainland and the island counties of Dukes and Nantucket. In the counties of Barnstable, Dukes and Nantucket there are no large centers of population and local water supplies are readily available which from present prospects are ample for all probable needs. Plymouth County contains but one large city, Brockton, amply supplied with water from sources situated in a region in which supplementary water supplies are readily available to meet future requirements. Plymouth, the next largest municipality in this county, has also an excellent water supply in a region of abundant further resources.

The greatest concentration of population in southeastern Massachusetts is found in the county of Bristol and is centered chiefly in the three principal cities — Fall River, New Bedford and Taunton. These cities contain many of the most important textile industrial plants in New England if not in the whole United States.

It will be shown later that Fall River and New Bedford, which together contain nearly 87 per cent. of the population of the three principal cities of southeastern Massachusetts under consideration, exclusive of the adjacent towns, are already using nearly all the water that their present sources of supply can safely be relied upon to furnish. If these cities continue to grow and to use more and more water, as has been the case in the past, additional water supplies must be secured, immediately in the case of Fall River, and within a very few years in the case of New Bedford, or a shortage of water supply will be experienced in the next dry period. Estimates of the population and of the quantity of water likely to be required for the supply of these cities which will be presented indicate that their population may be expected to double within the next fifty to sixty years if their growth continues approximately as shown by past experience. (See Diagram No. 1.) These estimates may seem large, but even if these cities should grow more slowly the quantities of water required for their use will equal the estimates within a comparatively few years beyond the time indicated. Fifty years is a short period in the life of a city, and many of the present inhabitants of these cities in the natural course of events will still be dwelling there at the end of that period.

*Director and Chief Engineer, Mass. Dept. of Public Health.


TAUNTON
NORTH WATUPPA POND
COPECUT HILL
ELEV. 358
FALL RIVER
LAKEVILLE
FREETOWN
ELDERS POND
TAUNTON PUMPING STATION
ASSAWOMPSETT POND
LONG POND
NOTES
ALL ELEVATIONS REFER TO BOSTON CITY BASE
WATER WORKS RESERVATIONS SHOWN
DARTMOUTH
HIGH HILL RESERVOIR (NEW BEDFORD)
ELEV 223.56
NEW BEDFORD
OLD STORAGE RESERVOIR
MIDDLEBOROUGH
Logging Swamp
SNIPATUIT POND
Cedar Swamp
ACUSHNET
ROCHESTER
MAP SHOWING
SOURCES OF WATER SUPPLY
FOR
CERTAIN MUNICIPALITIES
IN SOUTHEASTERN MASSACHUSETTS
SCALE

The industries of these cities have long been established and there is no reason why their growth should cease or even be materially restricted, in the immediate future at least, on account of the establishment of similar

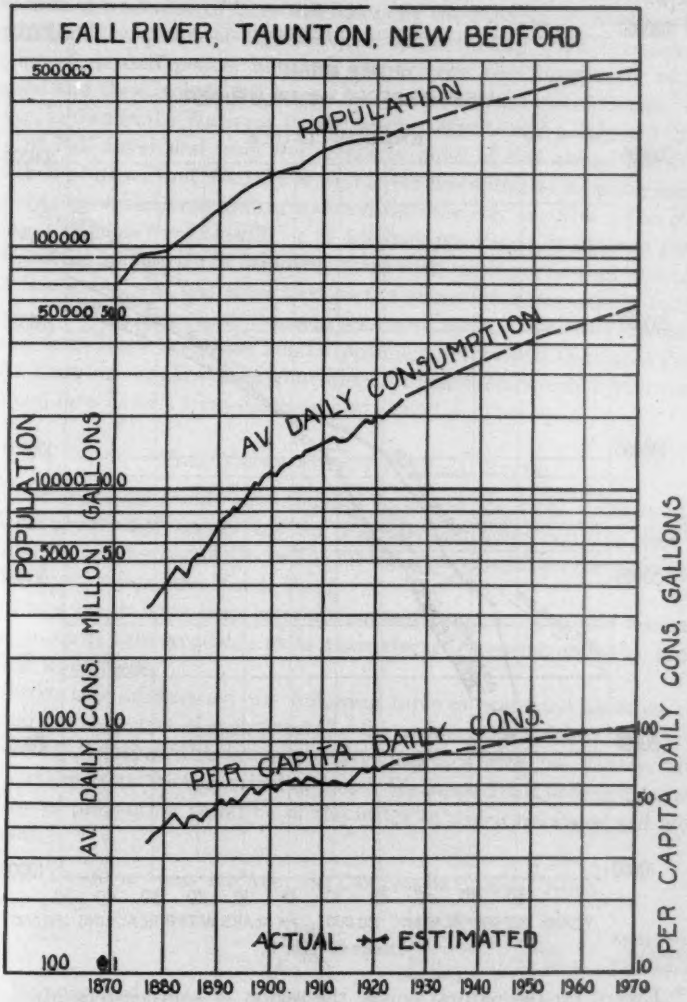


Diagram No. 1.

industries elsewhere or from any other cause that is apparent at the present time. The great manufacturing cities of England have not declined because of the growth of similar industries in England or in any of the other countries. On the contrary, those cities have grown steadily, and

for more than half a century their growth has been as rapid or even more rapid than is here estimated for the cities of southeastern Massachusetts, though the English cities have attained a much larger size. (See Diagram No. 2.)

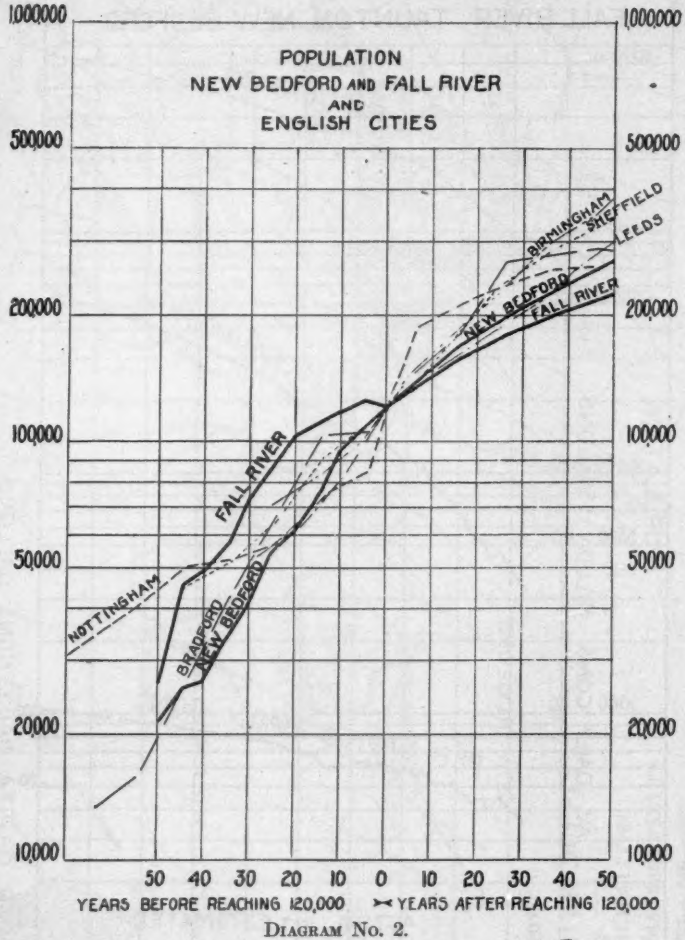


DIAGRAM NO. 2.

Except for the natural ponds, the region of southeastern Massachusetts is a singularly unfavorable one in which to obtain large quantities of unpolluted water for domestic uses within reasonable limits of cost. The valleys in general are wide and flat and are occupied commonly by extensive swamps. In consequence, the waters of the streams are usually highly colored and contain large quantities of organic matter. The rivers and water courses in many cases are exposed to pollution from towns and

villages on their watersheds and from manufactories producing large quantities of objectionable wastes which find their way into the streams. The contours of the valleys, as a rule, are poorly adapted for the construction of reservoirs of large size unless by the flooding of swamps which would produce waters of highly objectionable quality. Two remarkable groups of natural ponds, however, characterize the topography of this region, and they include the largest natural reservoirs in the State. One group, known as the Watuppa Ponds, lies adjacent to and partly within the city of Fall River and from the northerly pond of this group, known as North Watuppa Pond, the city of Fall River has obtained its water supply since water works were first introduced into the city in 1874. The other group, known as the Lakeville or Middleborough Ponds, is situated partly in Lakeville and partly in Middleborough with small portions in Freetown and Rochester, and has been used as the source of water supply for the cities of New Bedford and Taunton for many years, the former taking its supply from Little Quittacas Pond supplemented by Great Quittacas Pond, while Taunton supplies itself from Elder's Pond supplemented with water pumped into Elder's from Assawompsett Pond.

The Water Supply of Fall River.

The Watuppa Ponds have thus far furnished all of the water used in Fall River for water power and for domestic and manufacturing uses, — the domestic water supply, including all water supplied from the municipal works, coming from the North Pond.

These ponds have been carefully surveyed and mapped and accurate information is thus available as to their storage capacity and the areas of their watersheds.

From this information the following table is presented showing the original drainage area of each pond and the area and capacity of the North and South Watuppa Ponds respectively, together with the changes due to diversions from the watershed of North Watuppa Pond designed for the purpose of preventing pollution of the water to which reference will later be made.

Drainage Areas and Area and Capacity of Watuppa Ponds.

Pond.	Original Drainage Area (Sq. Mi.).	Drainage Area after Completion of Diversion Works (Sq. Mi.).	Area (Sq. Mi.).	Approximate Capacity (Mil. Gals.).
North Watuppa Pond	11.44	8.54	2.82	7 200
South Watuppa Pond	16.10	19.00	2.42	8 000

With the available records of rainfall for this region, which cover in some cases very long periods of years, and with the measurements of the flow of North Watuppa Pond which were maintained for a number of years by the city of Fall River, sufficient data are available for computing within narrow limits the probable safe yield of these ponds.

With this information estimates of the safe yield of North Watuppa Pond indicate that about 7 million gal. per day can be drawn from the pond without lowering the water level more than about five feet. It is possible by drawing the pond to a lower level, and thus utilizing a greater portion of the storage, to enlarge somewhat the yield of this source, but a draft of more than about 8 million gal. per day would be likely to exhaust the storage in the pond in a dry period. It is desirable to retain as large an amount of water in the pond as practicable for several reasons, especially for the purification of the water and the protection from the effect of possible pollution which storage affords, and the limit of 5 ft. in the draft from this pond is a reasonable one under the existing circumstances.

The quantity of water used in the city of Fall River since 1890, the population of the city, the consumption of water per capita, number of services and per cent. of services metered, are shown in the following table:

Year.	Population.*	Average Daily Consumption (Gallons).	Per Capita Daily Consumption (Gallons).	No. of Services.	Per Cent. of Services Metered.
1890	74 398	2 136 000	29	4 980	75
1891	77 359	2 356 000	30	5 247	76
1892	80 320	2 286 000	29	5 526	77
1893	83 281	2 334 000	28	5 793	78
1894	86 242	2 438 000	28	6 138	80
1895	89 203	3 167 000	35	6 372	82
1896	92 335	3 547 000	38	6 704	84
1897	95 467	3 670 000	39	6 422	93
1898	98 599	3 136 000	32	6 576	93
1899	101 731	3 581 000	35	6 783	94
1900	104 863	3 805 000	36	6 943	94
1901	105 043	3 619 000	34	7 075	96
1902	105 223	4 365 000	41	7 282	96
1903	105 402	4 278 000	41	7 502	96
1904	105 582	4 092 000	39	7 667	96
1905	105 762	4 407 000	42	7 744	97
1906	108 469	4 478 000	41	7 845	98
1907	111 175	4 941 000	44	7 956	98
1908	113 882	4 968 000	44	8 108	98
1909	116 588	5 340 000	46	8 316	99
1910	119 295	5 200 000	44	8 501	99
1911	120 394	5 177 000	43	8 790	99
1912	121 493	5 335 000	44	8 988	100
1913	122 593	5 636 000	46	9 289	100
1914	123 692	5 967 000	48	9 497	100
1915	124 791	6 086 000	49	9 793	100
1916	123 930	6 068 000	49	10 069	100
1917	123 069	6 346 000	52	10 210	100
1918	122 207	6 344 000	52	10 290	100
1919	121 346	5 907 000	49	10 382	100
1920	120 485	6 376 000	53	10 500	100
1921	120 485	6 971 000	58	10 671	100

* Populations for other than census years are estimated.

From the above table it appears that the quantity of water used in 1921 is practically equal to the safe yield of this source of supply. It will be noted that the per capita daily water consumption in the city of Fall River has in the past been less than in almost any other large manufacturing city in the State. This condition has been due to several causes, prominent among which is the fact that the South Pond and the Quequechan River furnish an ample supply of excellent water for manufacturing uses, and as the principal industries of the city are situated for the most part along this pond and river a large part of the water used for manufacturing and mechanical purposes is taken from those sources, thus relieving the draft from the municipal works. Furthermore, as the table indicates, meters have long been used very generally in Fall River and for many years practically all of the water used in the city has been supplied through meters. While the consumption per capita was much smaller than in any other city for many years after water works were introduced, it has been constantly increasing notwithstanding the use of meters, and there is no reason to doubt that with improving standards of living and with the introduction of new industries there is likely to be a still further increase in the consumption per capita which must be taken into account in planning for future extensions of the water supply system.

The selection of a source of additional supply involves the problem of the allowance to be made for the growth of population and increase in the use of water in order to furnish a reasonable basis for comparison of the relative advantages of available sources. The growth of Fall River, like that of the other textile cities in the State, has been uneven, having been very rapid in some periods and slower in others according to the varying prosperity of such manufacturing centers, most of which, though on the whole growing steadily larger, have shown a decline in population at times. The city of Lowell, for example, decreased slightly in population between 1855 and 1860 due to poor business conditions, and a marked decrease amounting to 5 837 in number occurred during the period between 1860 and 1865 due to conditions brought about by the Civil War. The city of Lawrence declined in population slightly between 1880 and 1885 though it has since increased rapidly with the establishment of the woolen industry in that city. The city of New Bedford, in common with many other places, declined in population during the period of the Civil War, from 1860 to 1865, but with the establishment of the textile industry that city has grown rapidly in recent years.

The city of Fall River grew very slowly in the period 1900 to 1910 due to unfavorable industrial conditions, and during the period of the great war, from 1915 to 1920, the population actually declined nearly 4 per cent. But it is unreasonable to conclude from the decline in the population of Fall River during the war that that city will continue to decline in population or even that it has reached the limit of its growth.

In view of the experience of other industrial cities, the only safe course in selecting an additional water supply is to assume that the population will continue to grow, more or less irregularly probably, as has been the case in the past, but on the whole continuously for a considerable time in

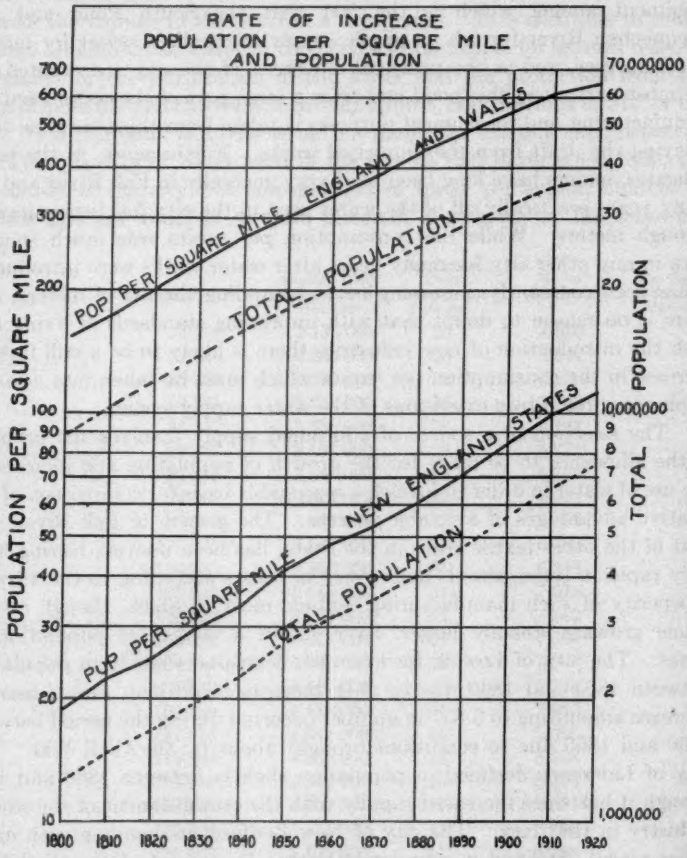


DIAGRAM NO. 3.

the future. In view of the growth of English manufacturing cities situated in a far more densely populated country than the United States or even New England to-day, it is unreasonable to assume that large manufacturing cities have reached the limit of their growth.

In diagram No. 2, the growth in population of several of the large industrial cities in England * was shown as compared with Fall River and

*Some of these cities have recently grown more slowly than formerly. Whether these conditions are due to a restricted area or to consequent overflow into adjacent districts has not been ascertained.

New Bedford both before and after the English cities had attained a population of about 120 000, which was the population of both Fall River and New Bedford in 1920. Diagram No. 3 shows the rate of growth of England and Wales and of the New England States.

Assuming that the city of Fall River will continue to grow about as it has in the past and allowing for a gradual increase in the consumption of water per capita, the quantity of water required for the supply of the city has been estimated as follows: (See also Diagram No. 4).

Year.	Population.	Per Capita Daily Consumption (Gallons).	Average Daily Consumption (Gallons).
1920*	120 485	52.9	6 374 000
1925	132 800	56.9	7 556 000
1930	144 500	60.6	8 757 000
1935	155 800	64.1	9 987 000
1940	166 800	67.4	11 242 000
1945	177 200	70.5	12 493 000
1950	187 500	73.4	13 763 000
1955	197 200	76.1	15 007 000
1960	206 800	78.6	16 254 000
1965	215 800	80.9	17 458 000
1970	224 800	83.0	18 658 000

While these estimates may seem unreasonably large it does not appear to be safe to take smaller figures in view of the circumstances which are likely to favor the further growth of this city, and in view also of the possible extension of its water supply system into adjacent territory.

The Quality of the Water of the Watuppa Ponds.

The water of the North Watuppa Pond is naturally soft, low in color and of excellent quality for domestic use. Many years ago, owing to the increase of population within the watershed of the pond, the city began the purchase of lands within the watershed and now owns nearly 60 per cent. of the area at present tributary to North Pond. In parts of this watershed on the westerly side of the pond in the drainage areas of Cress, Highland and Terry Brooks the population had increased to such an extent when the threat to the water supply was realized that it was found impracticable to purchase the lands except at a cost which was prohibitive, and in certain other small areas at the easterly side of the pond in the watershed of Nat and Ralph Brooks the increase in population had become such as to make the cost of protection by acquiring these areas excessive. The plan was then adopted of diverting the flow of water from objectionably populated drainage areas by means of intercepting drains, and a large intercepting drain was completed on the westerly shore of the pond in 1916 by which all of the flow from the populated areas in that part of the watershed is diverted into the South Pond. Plans were prepared at that

*Figures for 1920 actual, all others estimated.

time for diverting into the South Pond the flow of a large part of the drainage areas of Nat and Ralph Brooks on the easterly side of the pond, but the construction of the necessary works was interrupted by the war.

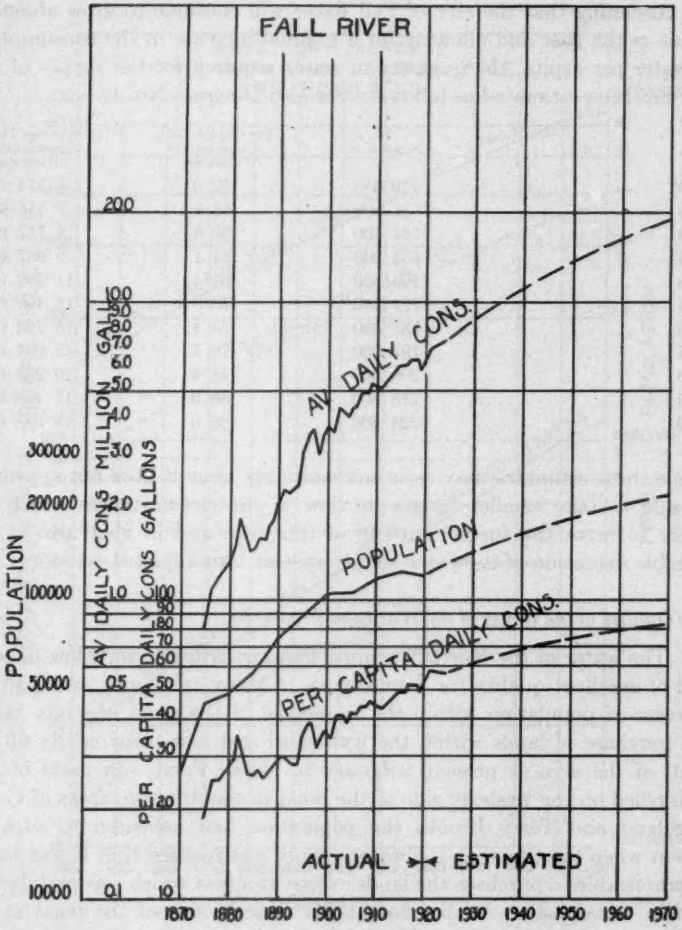


Diagram No. 4.

For nearly 30 years preceding the construction of the intercepting drain on the western shore of the pond in 1916, the quantity of organic and mineral matter in the water of North Pond had gradually increased, but since 1916 conditions have improved and the mineral and organic contents of the water have materially diminished.

Sources of Additional Supply.

In any consideration of an additional water supply for Fall River, the first source to which attention is naturally directed is the South Watuppa Pond apparently so readily available for the use of the city. The first considerable number of analyses of the water from the South Pond was made in 1898, and the results of those analyses show that while at that time the water contained larger quantities both of mineral and organic matter than that of the North Pond, the difference was not as marked as it has since become, and there is little doubt that the quality of the water of the South Pond was originally the same as that of the North Pond. With the growth of population and industries along the shores of the South Pond and the diversion into it of water from populated areas within the watershed of North Pond, the water of South Pond has become more and more polluted until the quantity of mineral matter in the water is more than double that of North Pond, while the proportion of organic matter present is even greater. If this water were now to be used as a source of water supply for the city of Fall River, filtration would of course be necessary, since the cost of preventing its pollution would now be impracticable. But as the city grows filtration itself would become inadequate unless the inhabitants were satisfied to use a highly mineralized water, as compared with the water supplies of other cities in the State, and one which would still further deteriorate in quality. While the poor quality of the water and the probability of further deterioration are not the only and probably not the most serious objections to the use of this source for the water supply of Fall River, the use of so polluted a water with the likelihood of further deterioration is not to be justified if waters of better quality are available.

South Watuppa Pond being obviously unfavorable as an additional source of water supply, the city of Fall River has considered other sources in this region including several small local sources and Long Pond of the Lakeville group. These investigations show that it is impracticable to secure additional water supply from local sources except in small quantities and at excessive cost, considering the amount obtainable. They show further that in the end recourse would inevitably be had to a much larger supply which could be obtained most favorably from the Lakeville Ponds, provided they were then in a condition in which they could be used for water supply purposes or could be made available for such use at a reasonable cost.

Since recourse must eventually be had to the Lakeville Ponds, it would be far more economical for the city to secure its water supply from those ponds in the beginning than to expend the large sums of money needed for the development of small additional supplies from local sources, and in the not distant future a further large sum for obtaining a satisfactory water supply from the Lakeville sources, the cost of which would un-

doubtedly be greater than if these sources were taken and their purity secured at the present time and might be prohibitive.

It should be noted here that, while North Watuppa Pond is the only source of water supply of the city of Fall River, the city does not as yet control the flowage rights in the pond but that under an existing agreement the owners of this flowage can draw freely from North Watuppa Pond so long as the level of the water remains above 40 in. below full pond. Furthermore, these owners can continue to draw 5 million gallons per day when the surface of the pond falls below 40 in. below full pond and 2 million gallons per day when the water is at or below 55 in. below full pond, no matter to what level the water may be lowered. Obviously, unless this draft can be discontinued, the safe yield of North Watuppa Pond, which now amounts to about 7 million gallons per day when 5 ft. of the storage is utilized, might be very materially reduced in a dry period by draft by the mills, while if any new source of water supply should be introduced much of the water could be diverted from the pond for the use of the mills on the Quequechan River. To meet this difficulty, the city has appointed a commission to secure the flowage rights in North Watuppa Pond, and it is understood that negotiations are now nearly completed whereby the city will secure these rights of flowage and exclude further draft from the pond for the use of the mills.

Water Supply of New Bedford.

The city of New Bedford has had a variable growth, having even declined in population during the Civil War as already mentioned. In recent years its growth has been rapid and has extended to the adjacent towns of Dartmouth, Acushnet and Fairhaven, two of which, Acushnet and Dartmouth, are supplied with water from the New Bedford water works.

The circumstances affecting the use of water in this city are quite different from those at Fall River, since there is no large supply of fresh water like South Watuppa Pond available for industrial use, and practically all of the water for manufacturing and mechanical as well as domestic purposes must be taken from the municipal works.

The water works system of the city of New Bedford was introduced in 1869 and for many years the use of water per capita was large, but unnecessary use and waste has been checked in recent years by the metering of all services.

The quantity of water used in the city of New Bedford in each of the years since 1895, together with the population, the consumption of water per capita, the number of services and the per cent. of services metered, is shown in the following table:

Year.	Population.*	Average Daily Consumption (Gallons).	Per Capita Daily Consumption (Gallons).	No. of Services.	Per Cent. of Services Metered.
1895	55 251	4 712 000	85	8 027	3
1896	56 689	5 259 000	93	8 447	4
1897	58 127	5 676 000	98	8 860	7
1898	59 566	5 908 000	99	9 014	8
1899	61 004	6 195 000	102	9 151	12
1900	62 442	6 318 000	101	9 280	15
1901	64 826	5 891 000	91	9 447	17
1902	67 210	6 372 000	95	9 612	18
1903	69 594	6 946 000	100	9 927	20
1904	71 978	7 022 000	98	10 166	21
1905	74 362	7 087 000	95	10 477	23
1906	78 820	6 917 000	88	10 764	26
1907	83 278	7 436 000	89	11 107	29
1908	87 736	7 488 000	85	11 516	31
1909	92 194	7 472 000	81	12 043	38
1910	96 652	7 864 000	81	12 769	48
1911	99 235	7 974 000	80	13 311	62
1912	101 818	8 281 000	81	13 643	73
1913	104 402	7 761 000	74	14 055	88
1914	106 985	7 432 000	69	14 407	96
1915	109 568	7 647 000	70	14 770	96
1916	111 898	8 516 000	76	15 126	96
1917	114 228	9 249 000	81	15 293	96
1918	116 557	9 716 000	83	15 376	99
1919	118 887	9 580 000	81	15 665	99
1920	121 217	10 085 000	83	15 962	99
1921	123 546	9 368 000	76	16 354	99

The consumption per capita was much smaller in the years of business depression, in 1914 and 1915, than before or since that time. A considerable reduction in the use of water again appears in 1921, a condition no doubt due to the mild winter and the excessive rainfall of the summer season by which that year was characterized and no doubt also by the prevailing business depression.

The future needs of the city in the matter of water supply have been estimated as follows: (See also Diagram No. 5).

Year.	Population.	Per Capita Daily Consumption (Gallons).	Total Consumption (Gallons).
1920†	121 217	83.2	10 085 000
1925	136 300	87.0	11 858 000
1930	151 700	90.6	13 744 000
1935	166 900	94.1	15 705 000
1940	181 900	97.5	17 735 000
1945	196 400	100.8	19 797 000
1950	210 800	104.0	21 923 000
1955	225 000	107.1	24 097 000
1960	239 100	110.1	26 325 000
1965	253 200	113.0	28 612 000
1970	267 100	115.8	30 930 000

*Populations for other than census years are estimated.
†Figures for 1920 actual, all others estimated.

As in the case of Fall River, the estimates may seem large but the favorable location of the city and the probable extension of its boundaries should be allowed for in any estimate of future growth.

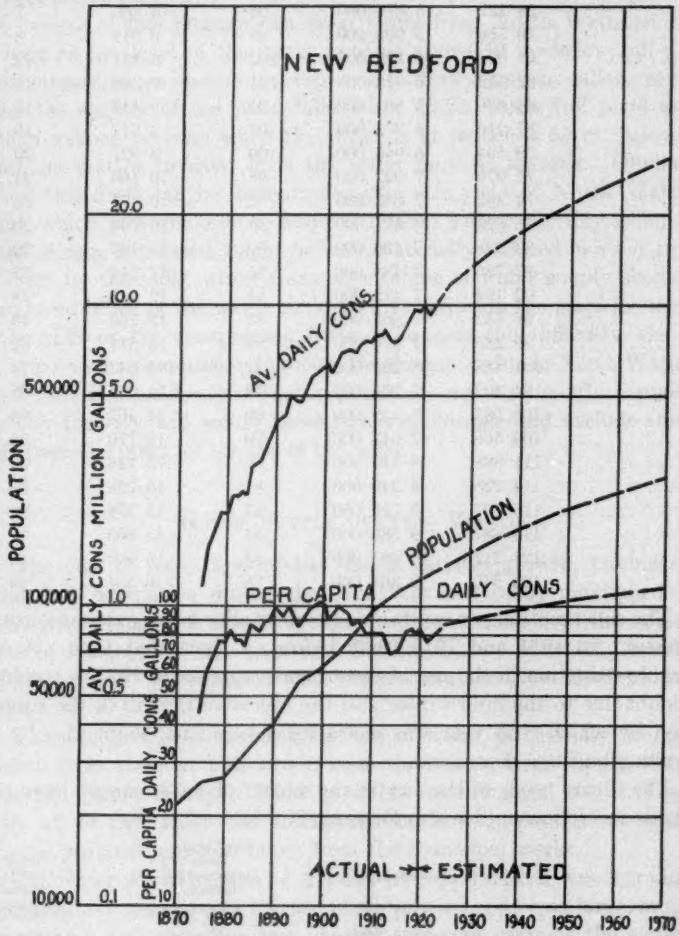


Diagram No. 5.

Sources of Supply.

The city of New Bedford was formerly supplied from a storage reservoir on the Acushnet River which furnished water which would now be regarded as of very poor quality for domestic use, being highly colored and heavily charged with organic matter, especially in the earlier years. In many respects the condition of the water of this reservoir is much the same

to-day. In 1886 the supply from the Acushnet Reservoir was supplemented by diversion into it through a canal, of water from Little Quittacas Pond, one of the Lakeville sources, and later on, in the year 1899, works were completed for supplying the city wholly from Little Quittacas Pond, supplemented with water flowing into it from Great Quittacas Pond. Under the authority of the Legislature these two ponds were separated from the remaining ponds of the Lakeville group and granted to the city of New Bedford as sources of water supply.

The area of the watersheds of these ponds, their area, average depths, and storage capacity are shown in the following table:

Pond	Area of Watershed Including Water Surface (Sq. Mi.).	Area of Water Surface (Sq. Mi.).	Storage Capacity (Mil. Gals.).
Great Quittacas Pond	11.42	1.81	4 990
Little Quittacas Pond	1.39	0.50	1 030

Quality of the Water of Great and Little Quittacas Ponds.

The water supplied by Great and Little Quittacas Ponds is soft and of good quality for domestic use. Soon after obtaining the right to the use of these ponds as sources of water supply, the city began securing the control of the lands within their watersheds and at the present time controls a large part of the watersheds of both Great and Little Quittacas Ponds and their tributaries. These lands were secured before the time when the use of the shores of ponds and banks of rivers as summer resorts had become as general as it is to-day and the lands were acquired at a small expense compared with the probable outlay that would now be necessary in case this opportunity had not been availed of at the right time. In consequence, there are very few dwelling houses within the watersheds of these ponds and the small population now living there is likely to diminish gradually as the remainder of these lands come under the control of the city. While these ponds furnish water which is soft and naturally of excellent quality for water supply uses, there are considerable areas of swamps on their watersheds, especially in the drainage area of Black Brook, the principal tributary of Great Quittacas Pond, and when it becomes necessary to use a greater portion of the storage than has been necessary in the past, the length of storage and its benefits in improving the quality of the water of tributary streams will be less effective than has hitherto been the case.

Safe Yield of Great and Little Quittacas Ponds.

In estimating the yield of these sources, it is necessary to allow for the retention of enough water in the ponds to secure sufficient benefit from storage to prevent serious deterioration in the quality of the water; but assuming that these ponds will be drawn down to a level of about 12 ft. below high water, using 80 per cent. of the storage capacity, their safe yield would be about 12 million gallons per day. This quantity is only about 28 per cent. in excess of the consumption of water in the city in 1921. The drawing down of the storage to such an extent would probably affect unfavorably the color and other qualities of the water.

Additional Water Supply.

The city of New Bedford at the present time supplies water to the adjacent towns of Dartmouth and Acushnet and to a small area in Freetown, the quantity used in Dartmouth in 1921 having been 56 000 gal. per day and in Acushnet 40 000 gal. per day. The city is also authorized to sell water to Lakeville.

The old storage reservoir is still available for use in emergencies. This reservoir has an area of about 300 acres and a storage capacity of about 400 million gallons, and receives the flow from a watershed of about 5.3 sq. mi. Its safe yield is probably about 3 600 000 gal. per day. The water of this reservoir has always been high in color and it contains a larger amount of organic matter than is found in the waters of most of the natural ponds in this region. This water could probably be used in an emergency if proper sanitary inspection were maintained within the watershed, but its quality at the present time would no doubt be objectionable unless filtered, and the expense of making it satisfactory for the use of the city would be large in proportion to the quantity of water obtainable.

An additional supply can be obtained more readily from Assawompsett Pond if approved by the Legislature than from any other source, since it is easily practicable to divert water from Assawompsett Pond into Great Quittacas Pond, these sources being separated only by a narrow causeway.

Water Supply of Taunton.

The city of Taunton had a population in 1920 of 37 137. This city has grown more slowly than New Bedford or Fall River and in one census period, between 1900 and 1905, the population slightly declined.

A water supply was introduced in the year 1876. The quantity of water used in the city of Taunton since 1895, together with the population, the consumption of water per capita, the number of services and the per cent. of services metered, is shown in the following table:

Year.	Population.*	Average Daily Consumption (Gallons).	Per Capita Daily Consumption (Gallons).	No. of Services.	Per Cent. of Services Metered.
1895	27 115	1 153 000	43	3 843	36
1896	27 899	1 179 000	42	3 955	36
1897	28 683	1 250 000	44	4 090	38
1898	29 468	1 302 000	44	4 233	38
1899	30 252	1 458 000	48	4 372	40
1900	31 036	1 645 000	53	4 502	41
1901	31 022	1 738 000	56	4 618	42
1902	31 008	1 512 000	49	4 698	44
1903	30 995	1 531 000	49	4 753	45
1904	30 981	1 771 000	57	4 837	45
1905	30 967	1 910 000	62	4 911	46
1906	31 625	1 915 000	61	4 983	46
1907	32 284	2 144 000	66	5 043	47
1908	32 942	2 247 000	68	5 194	48
1909	33 601	2 168 000	65	5 237	50
1910	34 259	2 150 000	63	5 344	50
1911	34 639	2 233 000	64	5 301	53
1912	35 020	2 366 000	68	5 420	54
1913	35 400	2 338 000	66	5 526	56
1914	35 781	2 373 000	66	5 635	58
1915	36 161	2 222 000	61	5 755	59
1916	36 356	2 480 000	68	5 846	61
1917	36 551	2 792 000	76	5 930	62
1918	36 747	3 154 000	86	5 979	63
1919	36 942	3 090 000	84	6 013	65
1920	37 137	3 395 000	91	6 091	71
1921	37 333	3 237 000	87	6 170	77

It will be noted that the consumption of water per capita has increased gradually notwithstanding the steadily increasing percentage of metered services.

The probable future needs of the city of Taunton in the matter of water supply have been estimated as follows: (See also Diagram No. 6).

Year.	Population.	Per Capita Daily Consumption (Gallons).	Total Consumption (Gallons).
1920†	37 137	91.4	3 394 000
1925	40 000	93.9	3 756 000
1930	42 900	96.4	4 136 000
1935	45 800	98.9	4 530 000
1940	48 700	101.4	4 938 000
1945	51 600	103.9	5 361 000
1950	54 400	106.4	5 788 000
1955	57 200	108.9	6 229 000
1960	60 000	111.4	6 684 000
1965	62 800	113.9	7 153 000
1970	65 600	116.4	7 636 000

* Populations for other than census years are estimated.
† Figures for 1920 actual, all others estimated.

Sources of Water Supply.

The city of Taunton formerly obtained its water supply from a filter gallery near the banks of the Taunton River supplemented with water taken directly from the river. Subsequently, in 1894, works were com-

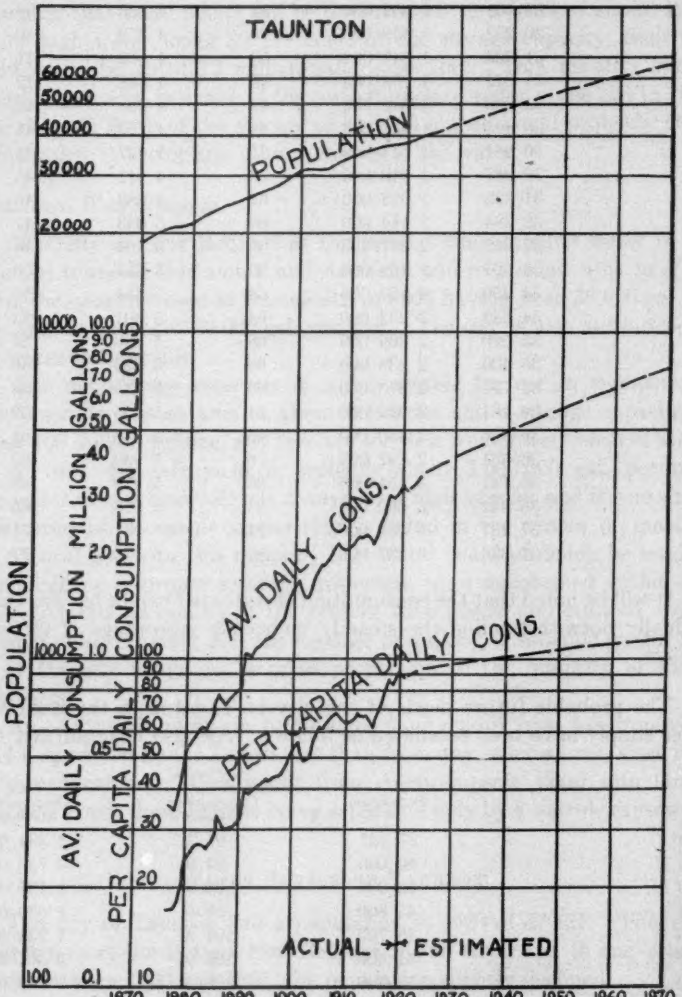


Diagram No. 6.

pleted for taking water from Elder's and Assawompsett Ponds of the Lakeville group. At the present time water is pumped from Assawompsett Pond at a pumping station located on its westerly shore about half a mile

north of the outlet of Long Pond into Elder's Pond, whence it flows by gravity to a pumping station in Taunton from which it is supplied to the city. The water supplied in this way is soft, very low in color and of excellent quality for domestic use. The quantity of water used from these ponds by the city of Taunton is only a small portion of their safe yield in a dry period.

The city of Taunton has acquired all the lands about Elder's Pond and considerable areas along the shore of Assawompsett Pond for the protection of its water supply, but the amount so controlled is small in proportion to the entire shore line of Assawompsett Pond and its tributaries, Long and Pocksha Ponds.

The Lakeville Ponds as Sources of Water Supply for the Joint Use of the Cities of Fall River, New Bedford and Taunton and Other Municipalities in Their Vicinity.

In connection with the investigation of the water supply needs and resources of the Commonwealth, under the provisions of Chaper 49 of the Resolves of 1919, the available information relative to the area and capacity of the Lakeville Ponds was collected in coöperation with the authorities of New Bedford and Taunton and was supplemented with such further surveys and soundings as were necessary to determine the area, depth and capacity of all the larger lakes, the areas of their watersheds, the extent of the swamps thereon, and the number of dwelling houses, cottages and other structures within their watersheds. From that report the following table is taken showing the area, capacity, elevation of water surface and area of watershed of each of these ponds:

	Area of Watershed Including Water Surface. (Sq. Mi.).	Area of Water Surface. (Sq. Mi.).	Storage Capacity. (Mil. Gals.).	Elevation at Which Data Are Taken.* Boston City Base.
Long Pond	21.22	2.80	5 730	61.45
Assawompsett and Pocksha Ponds	13.17	4.20	8 900	60.79
Great Quittacas Pond	11.42	1.81	4 990	60.07
Little Quittacas Pond	1.39	.50	1 030	59.57
Elder's Pond	.53	.22	692	93.54
Totals	47.73	9.53	21 342	....

The ponds are divided naturally into two groups each of which is tributary to Assawompsett Pond, the largest and under original conditions the lowest of all. The waters of Elder's Pond flow naturally into Long Pond and thence into Assawompsett Pond near its southerly end, while on the easterly side of the watershed the waters of Little Quittacas Pond flow naturally to Great Quittacas Pond and thence in times of high flow

*These elevations, observed on March 18, 1920, are the highest recorded during the progress of the surveys.

into Pocksha Pond which is practically an arm of Assawompsett Pond on its easterly side. The Nemasket River, which forms the outlet of the entire group, flows northerly from the northerly end of Assawompsett Pond. The conditions affecting these ponds have been materially changed since the cities of New Bedford and Taunton began drawing water from them, and in dry seasons under present conditions little or no water overflows from Great Quittacas Pond into Pocksha Pond and no water runs from Elder's Pond to Long Pond. A dam has been constructed by the city of New Bedford, as authorized by the Legislature, between Great Quittacas and Pocksha Ponds to prevent water from the latter flowing into Great Quittacas Pond except in times of high flow, but the surplus water of Great Quittacas Pond discharges into Pocksha Pond.

Quality of the Water.

The water of all the Lakeville Ponds is very soft and naturally of excellent quality for water supply uses. The water of Long Pond, which receives the flow of nearly half the aggregate drainage area of the ponds, is usually considerably colored, but in the remaining ponds the color is not at any time excessive and the waters supplied from Little Quittacas Pond and Elder's Pond to New Bedford and Taunton, respectively, are among the most desirable waters of the State. The comparatively low color of the water of most of the ponds is in marked contrast to that of their chief tributaries, some of which are very highly colored. This high color is due to the passage of the water through swamps of which the watersheds of these ponds, like most watersheds in this part of the State, contain extensive areas, and it will be necessary in order to maintain and improve the quality of the water of the ponds to drain or otherwise better the conditions in the swamps. These swamps have an aggregate area of about 5.34 sq. mi., or a little over 3 400 acres, and fall naturally into two groups. One includes those which are adjacent to the streams tributary to the ponds and includes the swamps adjoining Black Brook, Fall Brook and a brook flowing from Elder's Pond which contain in the aggregate some 2 400 acres. The brooks which drain these extensive swamps have sufficient fall for the most part to allow of their adequate drainage, and a great improvement in the color of these waters could no doubt be effected thereby. The second group of swamps includes those which are adjacent to the shores of the ponds themselves with an aggregate area of a little over 1 000 acres and a total frontage along the ponds of about 41 800 ft. These swamps are about 48 in number and occupy about 23 per cent. of the shore line of the ponds from which they extend back varying distances of from 100 to 4 600 ft. Their surfaces lie, for the most part, little above the normal level of the high-water surfaces of the ponds, but by drainage, diking or other means they can either be drained or so treated as to prevent them from affecting seriously the quality of the waters of the ponds.

The high color of the waters of the tributaries is rapidly reduced when exposed to sunlight and other influences in their passage through the ponds, in which the color is largely removed by bleaching, by dilution with the rainfall and with water not affected by swamps, and by other actions which take place in large storage reservoirs. When the water finally reaches the outlet of the last pond of the series the color is reduced to a comparatively small amount.

The extent of this improvement depends largely, no doubt, upon the time which elapses in the passage of the water through the ponds, and if the water in storage should be drawn to too low a level the colored water of the tributaries could pass through more rapidly and there would be less improvement than at the present time. For this reason, while it is probable that for many years the draft on the ponds by the cities in question would affect but little the color of the water, it is important that as the draft increases the color of the waters of the tributaries shall be reduced by drainage so far as is necessary and practicable to prevent them from raising the color of the water in the ponds to an objectionable degree.

Protection of the Purity of the Water of the Lakeville Ponds.

The watersheds of the Lakeville Ponds contain no villages of considerable size and no important manufacturing establishments producing foul wastes are found within their limits. The permanent population is, in fact, very small and widely scattered and danger of pollution from it nearly negligible; but while the population living permanently within the watersheds of these ponds is very small compared with their area at the present time, there is a considerable and growing population in the cottages and camps about the shores of Long, Pocksha and Assawompsett Ponds, and, while a small area is under public control along the shores of Assawompsett Pond, the remaining lands are still in private ownership and are open to settlement. The total number of dwelling houses, camps, and other buildings located within the watersheds of these ponds amounted at the time of the recent surveys to about 342. A classification of the lands within approximately 1 400 ft. of these ponds is given in the following table:

Land.	Acres.
Cottage and camp lots	228
Private estates and parks	171
Farm land	92
Heavily wooded land	609
Scrub land	1 060
Swamp land	836
Land owned by municipalities	108
Total	3 104

The assessed valuation of the buildings and land privately owned and included in the foregoing table is estimated as follows:

Buildings	$385 000
Land	304 000
Total	$689 000

These large natural reservoirs, lying at the doors of the principal municipalities in southeastern Massachusetts, are a great advantage to these cities and towns when the cost of artificial storage in this region is taken into consideration. The cost of construction of suitable artificial reservoirs for these cities would be great and the further cost of improving the quality of their waters sufficiently to equal that obtainable at present from the Lakeville Ponds would require a very large outlay either for the preparation of the reservoir site or for purification works, together with the cost of operation and maintenance. Moreover, in order to secure a quantity of water equal to the yield of the Lakeville Ponds and their tributaries it would be necesary, in all probability, especially if each city should undertake the development of independent supplies, to develop and use two or more watersheds for the purpose.

On the other hand, the Lakeville Ponds, the largest natural ponds in the State, are reservoirs of very large capacity, already in existence, well adapted for the purpose, and requiring no costly dams or other works to make them available for water supply uses beyond a regulating weir at the outlet of Assawompsett Pond. An idea of what it might cost these cities to construct reservoirs of similar size may be gathered from a consideration of the cost of some of the artificial reservoirs in the State which furnish water of similar quality. The Sudbury Reservoir, which holds about half the aggregate amount of water contained in Assawompsett, Long and Pocksha Ponds, cost, exclusive of water damages and of the cost of works for protecting the quality of the water, $2 923 152.96 or about $403 per million gallons. If reservoirs of equal size had to be constructed artificially for the water supplies of Taunton, Fall River and New Bedford, the cost at the same rate would be from 5 to 6 million dollars. If the cost were no greater proportionately than that of the Borden Brook Reservoir of the city of Springfield, constructed under more favorable conditions than are found in southeastern Massachusetts, the construction of reservoirs of the size of the Lakeville Ponds would cost $1 250 000 even at pre-war prices; but the water of Borden Brook Reservoir is subsequently filtered.

In the presence of these great natural ponds, available for water supply uses in their immediate neighborhood, the cities of southeastern Massachusetts are favored above other cities of the State. If these cities can secure united action they can obtain the right to use the Lakeville Ponds

as their future sources of water supply. By uniting in securing and protecting these lakes they will obtain storage reservoirs of great size, requiring no outlay for construction, which lie close to their doors and which with comparatively little outlay will furnish unpolluted water of excellent quality for the use of their inhabitants for a very long time in the future without treatment of any kind. That so remarkable an opportunity will be neglected through mutual distrust or differences as to minor matters of detail such as methods of procedure, or of control or operation of the works is, of course, not to be thought of; but failure to grasp this great opportunity in season and to make this water supply available to the cities in the most reasonable and practicable way may result in a serious increase in the cost of the project and perhaps in preventing their development in such a way as to secure the most satisfactory water supply obtainable from these sources.

THE WATER SUPPLY OF FALL RIVER.

BY H. K. BARROWS.*

[*September 14, 1922.*]

Seven years ago, in September, 1915, the writer presented a paper at the Annual Convention of this Association entitled "Improvements to the Water Supply of the City of Fall River." At that time most of the improvements described were still in process of construction. The purpose of this paper is to complete the description of these works and describe some of the further projects, particularly for additional water supply, which have been studied since that time and are now nearly at the construction stage. Many of the mills in Fall River utilize the waters of Quequechan River, supplied from the South Watuppa Pond, and as the problems involved in assuring an ample water supply for these mills are closely connected with those of the municipal water supply, this paper will include a description of the plans for the improvement of the Quequechan River.

As described in the previous paper, the history of the municipal water supply of Fall River has been most interesting and has involved some perplexing questions considered at much length and over many years in the courts. Following is a brief summary of legislation, decisions, etc., as described in the previous paper, bringing matters up to about 1913.

NORTH WATUPPA POND — SUMMARY OF LEGISLATION, ETC., TO 1913.

1874. Water Act authorizing use of 1 500 000 gal. per day by city.

1880. Suit by Watuppa Reservoir Co. for damages under Act of 1874. Company awarded $70 000.

1886. Act authorizing 1 500 000 gal. per day additional use of water by city.

1888. Suit of Watuppa Reservoir Co. for additional damages not sustained. Chief Justice Morton held that "State had right to use the waters of the great ponds, etc., without compensation."

1891. Supreme Court reversed decision of 1888 because Watuppa Reservoir Co. were successors in title to grantees of Plymouth Colony.

1892. Agreement made by city and Watuppa Reservoir Co. whereby Company can use unlimited water to 40 in. below full pond. City can use water for water supply, but does not control storage.

1895. Watuppa Reservoir Commission established by city, to control and protect its water supply.

* Consulting Engineer, Boston, Massachusetts.

1897. City took by condemnation entire North Pond to "preserve and protect water supply" — but in accordance with agreement of 1892.

1907. Regulations protecting North Pond made by State Board of Health.

1909. Act authorizing city to borrow money for construction of works and protection of water supply. *Intercepting drain* built under this act, (in 1915).

The most important work under construction for the improvement of the water supply in 1915 was that of the intercepting drain on the west shore of North Watuppa Pond, built for the purpose of preventing drainage from various populated districts entering the North Pond. Details of the different sections of this drain are presented in the previous paper, the entire length being about 14 000 ft., mostly of reinforced concrete, open section, varying in width from 6 to 10 ft.

The contract for this work was let early in 1915 and the work completed by about September 1, 1915, the total construction cost approximating about $190 000. Some of the more interesting details of cost are appended to this paper.

This intercepting drain was put in commission in January, 1916 and has been in use since that time. It was an excellent piece of construction work and the lapse of some seven years shows the concrete in practically as good condition as when built. (See Figs. 1-4 inclusive.)

As a considerable part of this drain is open section, whereby a very substantial saving in first cost resulted, it has required some annual cost of maintenance to clear out stones and debris, and occasionally some ice, always likely to accumulate in a structure of this kind. This has cost about $100 annually, as an average cost for the first five years.

Another feature which has been of interest in the operation of this drain is that of ice effect. The winters of 1918 and 1920 were unusually severe, resulting in solid ice of considerable thickness forming in the open section of the drain. Careful watch was kept of this situation, particularly in 1918, to prevent any possible ice jams and overflow of the drain, but in both 1918 and 1920 the thick ice which formed gradually softened and went out in the early spring without bad effect.

The sanitary results obtained by the operation of this intercepting drain have been excellent, as shown by the following table, giving the results of bacteriological examinations before and after its construction. The marked pollution of the waters of Highland, Terry and Cress Brooks, all diverted by the drain, is apparent, as is also the effect of this pollution upon the quality of water at the water-works intake, before the drain was built.

King Philip and Blossom Brooks lie on the easterly side of the pond and still contain considerable areas not yet acquired by the City and which eventually must be taken.

Nat and Ralph Brooks are badly polluted and must be diverted to the South Pond as further noted.

FIG. 1 — JUNCTION OF 10 FT. OPEN AND CLOSED SECTIONS. FALL RIVER INTERCEPTING DRAIN — OCTOBER, 1915.

FIG. 2 — HIGHLAND BROOK INTAKE. FALL RIVER INTERCEPTING DRAIN — AUGUST, 1915.

FIG. 3. — AUXILIARY PUMPING STATION AND INTAKE, ALSO 10 FT. OPEN SECTION OF INTERCEPTING DRAIN — NOVEMBER, 1921.

FIG. 4. — 8 FT. OPEN SECTION OF INTERCEPTING DRAIN — NOVEMBER, 1921.

NORTH WATUPPA POND — BACTERIOLOGICAL EXAMINATIONS OF WATER BY CITY DEPARTMENT OF HEALTH — DR. J. H. WALSH, BACTERIOLOGIST.

Before 1915, (construction of Intercepting Drain).

	Excellent.	Reasonably Good.	Doubtful.	Extremely Doubtful.
Intake at Pumping Station	37%	47%	11%	5%
Highland Brook	0	7	50	43
Terry Brook	0	8	42	50
Cress Brook	0	0	41	59
King Philip Brook	27	56	13	4
Blossom Brook	20	62	18	0
Ralph Brook	0	19	63	18
Nat Brook	0	0	40	60

During 1920

	Excellent.	Reasonably Good.	Doubtful.	Extremely Doubtful.
Intake at Pumping Station	76%	24%	0%	0%
Highland Brook, Terry Brook, Cress Brook	Water diverted to South Pond			
King Philip Brook	40%	43%	9%	8%
Blossom Brook	13	51	23	13
Ralph Brook	11	35	31	23
Nat Brook	0	23	40	37

Note: — Percentage is of number of samples examined.
Classification as follows: —
Excellent — No Colon in 10 c. c.
Reasonably good — Colon in 10 c. c. and not in 1 c. c.
Doubtful — Colon in 1 c. c.
Extremely doubtful — Colon in $^1/_{10}$ c. c. and less.

The construction of this intercepting drain was following the policy of the Fall River Reservoir Commission (consisting of the Watuppa Water Board, acting with the Mayor and City Engineer), which has been to either acquire all land within the drainage area of North Watuppa Pond or, where the conditions of growth and population made this too expensive, to divert these waters to South Watuppa Pond, where they would still be useful for mill water-supply purposes. (See Fig. 5.) In carrying out this policy some 3 300 acres of land around the South Pond has been purchased by the city at a cost in excess of $300 000 as well as the construction of the intercepting drain just described.

There still remains an area of a little over half a square mile constituting a portion of the village of North Westport on the southeasterly shore of the pond, and included in portions of the drainage areas of Nat and Ralph Brooks, which must be diverted to the South Watuppa Pond. Surveys and plans for this work were made during 1915–17 and this project is now ready for construction. It involves the construction of an earth fill dam about 1 600 ft. long and 12 ft. high, with a cut off of sheet piling, across the inlet of the pond in this vicinity, with a 48-in. outlet conduit to South Watuppa Pond about 225 ft. long. The waters of a consid-

erable portion of Ralph Brook will be brought by means of a 45-in concrete conduit, about 2 700 ft. long, to the pond back of this diversion dam and also discharged into the South Watuppa Pond. The total

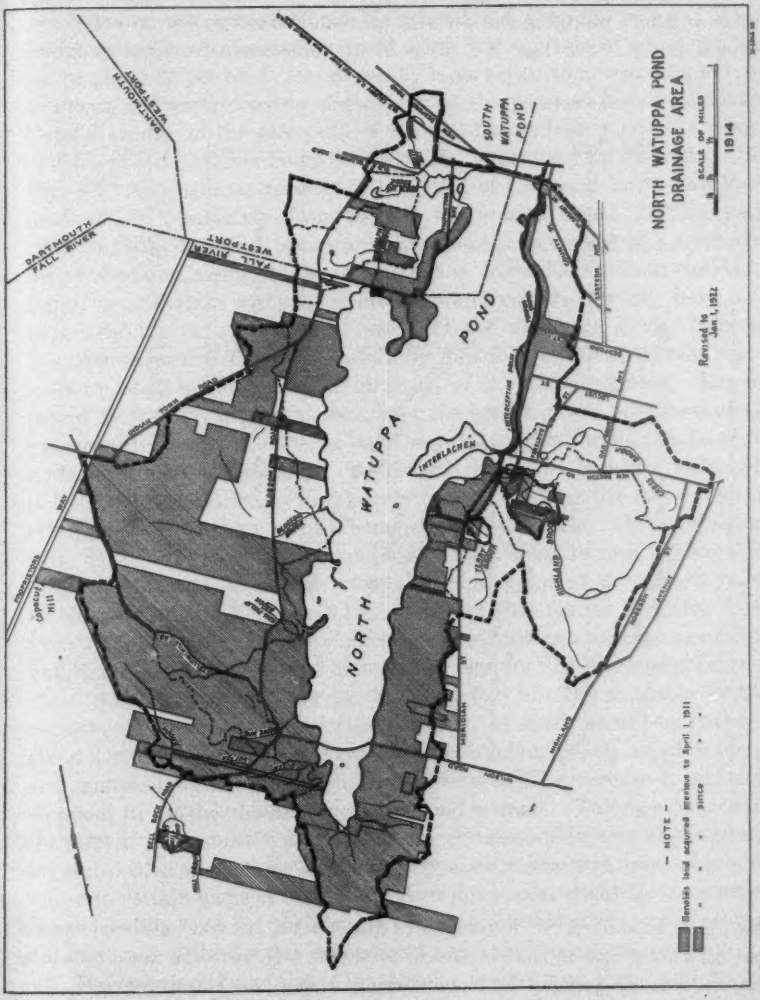


FIG. 5.

estimated construction cost of this work based on approximate normal costs, is about $75 000. At present this cost would probably exceed $100 000. The sanitary conditions on portions of Nat and Ralph Brooks are bad, as will be noted by the data in the previous table, although the entrance of these brooks is at a very considerable distance from the

water-works intake. The construction of this project will therefore proceed as soon as costs become somewhat further stabilized.

The other several improvements under way in 1915, which included (1) a 7 million gal. Platt high duty pump at the main pumping station, (2) an auxiliary pumping station with an 8 million gal. motor operated centrifugal pump, (See Fig. 3.) (3) a 36-in. force main from the pumping

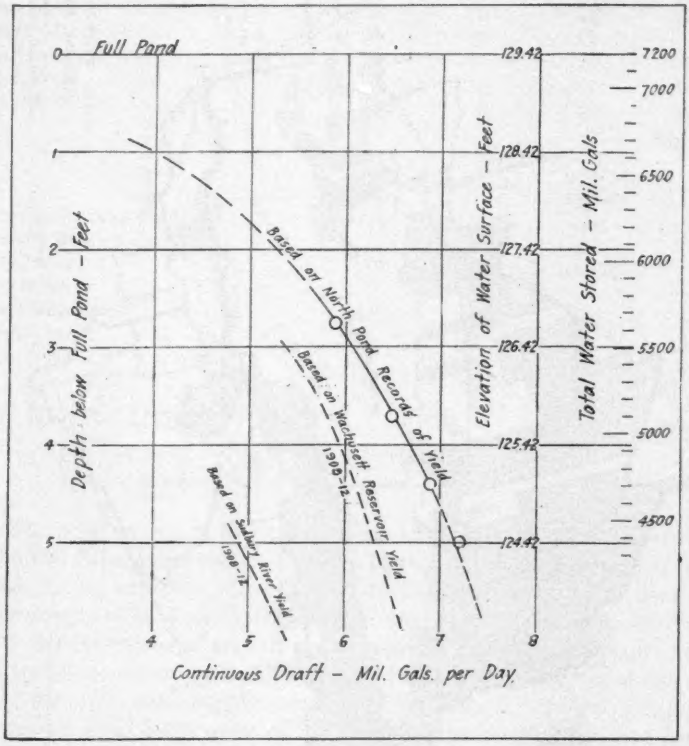


FIG. 6. — YIELD OF NORTH WATUPPA POND.

station at Eastern Ave. (a distance of about 3 400 ft.) have all been carried out, at a total cost in the vicinity of $100 000. In 1918 the main pumping station was fireproofed by constructing a new steel and concrete floor finished with tile and building brick walls faced with white enamel brick for a height of 10 or 12 ft. The plastering above this level, as well as the interior of the station generally, was also renovated and painted, the total cost of the work aggregating about $10 000. The roof was also re-slated, at a cost of about $3 200, so that the main building, built in 1873, is now in excellent condition.

During the period of the war of course only necessary construction was carried on, practically that just described, with some necessary pipe extensions, but since 1916 a careful and thorough investigation has been made of the question of additional water supply.

The drainage area of North Watuppa Pond when the Nat and Ralph Brook diversions are completed will total 8.54 sq. mi. of which 2.82 sq. mi. or about 33 per cent., (an unusually large proportion, resulting in large evaporation losses) consists of the area of the pond at high water level. Careful studies of the safe yield of the pond have been made, the results of some of these studies being shown on the accompanying diagram. (See Fig. 6.) Approximate records of the yield of the pond have been kept, more or less completely, from 1899 to the present time. For the years 1899 to 1901, inclusive, accurate measurements by means of a weir were made of water passing the Narrows, that is, from the North to the South Pond, and accurate pumping records of water used by the city have been kept over the entire period. Since 1911 the discharge at the Narrows has been measured fairly accurately by means of frequent current meter measurements made under the direction of the City Engineer. For the period 1902–1910, inclusive, records of the height of the pond and of the gate conditions at the Narrows have been kept, which serve as a basis for a rough estimate of discharge. Unfortunately the dry period of 1908–1912 is thus covered chiefly by the poorer records, making the determination of safe yield from these records somewhat questionable. On the diagram (Fig. 6) the safe yield of the pond based upon these records is shown for different amounts of storage utilized. Similar curves are shown based on the yield of the Wachusett Reservoir and that for the Sudbury River from 1908 to 1912. In this connection note that the average rainfall at Fall River is in the vicinity of 44 in., while that for the Wachusett Basin is about 45.3 in. and that for the Sudbury 44.6 in. The available storage capacity of the North Pond in the first 5 ft. of draft, as will be noted, is about 2 800 million gallons or some 330 million gallons per sq. mi. of drainage area, and keeping in mind the form of these curves, the increase in safe yield obtained by further pulling down the pond is small. Taking into account the present limitations in draft due to the elevation of intakes at the pumping stations, as well as the undesirablility of exposing large areas of muddy shores in certain parts of the pond it does not appear desirable to count on more than 5 ft. or 6 ft. at the most, of depth, for which amount of storage the safe yield of the pond is between 6.5 and 7 million gallons per day.

The consumption of water by the city is shown on Fig. 7 and, as will be noted, for the year 1921 this consumption reached an amount of 7 million gallons per day, or just about the safe yield of the pond, so that the necessity of providing an additional supply is apparent. In 1916, a Water Act was obtained by the city which gave it authority to make investigations and to use as a water supply any water source within the limits of Fall River and also that of Mill Brook in the town of Freetown, this being along

lines suggested by the State Department of Health in reports prior to that time. Under this Act, surveys and investigations were made during 1916, covering possible sources and including, in addition to Mill Brook, which lies northerly from North Watuppa Pond, the possible use of Bread

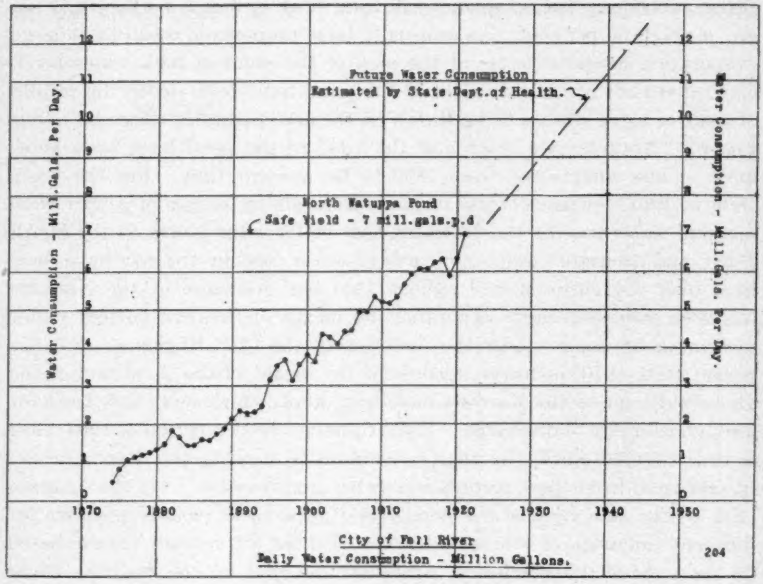


FIG. 7.

and Cheese Brook, a small stream lying easterly from the pond, and Copecut River lying northeasterly — all of which could be adapted to provide a further supply which would flow by gravity into North Watuppa Pond. The preliminary results of these investigations are given in the accompanying table:

COMPARISON OF PROJECTS FOR ADDITIONAL WATER SUPPLY. *

Item.	PROJECT AND DRAINAGE AREA.		
	Mill. (3.35 Sq. Mi.).	Bread and Cheese (2.65 Sq. Mi.).	Upper Copecut (3.13 Sq. Mi.).
Cost (not including water rights)	$438 100	$491 000	$751 900
Safe yield (mil. gal. per day)	2.90	2.40	2.30
Cost per mil. gal. (per day safe yield)	$151 000	$204 000	$327 000
In conjunction with full use of North Pond would give city a safe supply until about	1938	1935	1934

* Report of November 17, 1916 — H.K.B.

The results shown therefore led to the making of test borings at the Mill Brook dam site and a more accurate determination of the cost of this project during the first half of 1917. The results of these further investigations indicated that the preliminary figures of cost were ample and that the construction cost of the Mill Brook project should not exceed about $375 000 on the basis of approximate normal costs, not including the cost of any water rights, the latter chiefly comprising use of water at the Crystal Spring Bleachery in the town of Assonet.

Before the completion of these investigations the State Department of Health advised the consideration of a supply of water from Long Pond lying some ten miles east of the city and a careful investigation was also made of the use of this pond, including a pumping station and pipe line to North Watuppa Pond. This project proved to be much greater in first cost than the Mill Brook, owing largely to the necessary takings of land and buildings around Long Pond. Furthermore, the proportionate cost was greater than for the Mill Brook supply, viz. per million gallons and daily capacity, as indicated by the following cost estimates:

ESTIMATED COST OF 3 MILLION GALLONS PER DAY WATER SUPPLY FROM LONG POND.

(*Based upon normal cost conditions.*)

Pipe Line	$250 000
Intake, Pumping Station, Equipment, etc.	40 000
Cost of Pumping	240 000
TOTAL COST (exclusive of land and water rights or control works)	$530 000

The State Department of Health, however, took the attitude that it was time to begin the development of the larger supply in the Lakeville Ponds and did not approve the further consideration of the Mill Brook supply. They further recommended that full control of the North Watuppa Pond be obtained by the city before any further action was taken toward obtaining an additional supply.

As explained in the paper of 1915, the North Watuppa Pond is not a "Great Pond" legally, as the suit of 1891 established that the Watuppa Reservoir Company, an association of various mills along Quequechan River, were successors in title to grantees of Plymouth Colony, to whom the land under and on both sides of the outlet of the pond was conveyed on March 5, 1680, to Church, Gray and others for £1 100. This grant, known as the Pocasset Grant, included all of the South Pond and about half of the North Pond. Since 1892 the city has been working under an agreement with the mills whereby it can use an unlimited amount of water from the North Pond for purposes of municipal water supply, but, on the other hand, the mills can also make use of this water without restriction down to a level of about 40 in. below full pond. One of the other

terms of this agreement is the so-called "Tax Rebate," whereby taxes on the water power of these mills are rebated by the city — this amounting to some $6 000 or $7 000 per year, depending on the tax rate. Under this agreement of 1892 it is obvious that the city had only partial control of the storage of water in the North Pond. Consequently for the last few years it has escaped a shortage of water only by good luck.

The Water Act of 1916 provided for the taking of the North Pond rights by condemnation, if necessary. It was felt, however, that a settlement might be effected by agreement, and negotiations were accordingly carried on during the years 1919 and 1920, finally resulting in an agreement between the mills and the city which was accepted by the City Council in March, 1920. This agreement provided, in brief, that the agreement of 1892 with the mills be terminated and that the city should have full control and rights in the North Watuppa Pond upon payment to the Watuppa Reservoir Company of the sum of $75 000, and further provided that the operation of the Quequechan River improvement whereby the water supply of the South Pond would be better conserved for the use of the mills, should also be carried out.

The improvement of the Quequechan River is a project which has been before the city for many years. While the mills have had the control of the South Watuppa Pond, no attempt has been made to adequately utilize its storage capacity, with the result that at various times within the last dozen years the waters of the Quequechan River have become so low that not only has the river itself been most unsightly, but the mills have in many cases had to shut down for lack of water to operate them.

These constantly recurring conditions becoming well-nigh intolerable finally resulted in legislation and general investigation of the matter of improving Quequechan River, for which plans were submitted in 1915 to the City Council, providing, in brief, for the filling in of the river channel and flats and the handling of the river water in a three level reinforced concrete conduit in addition to a general system of sewers and drains for the district. This scheme of improvement involved so great a cost, however, (about $3 000 000 in first cost) that the plans were not accepted by the City Council and in 1916 a new Quequechan River Commission was created and plans prepared on a more economical basis. In brief, these provided for retaining the greater portion of the present river basin and dredging it to greater depth, as well as a district sewer system, while the storage capacity of the South Watuppa Pond is to be utilized by a dam and pumping station at the Sand Bar at the outlet of the pond. The first cost of this scheme as first proposed approximated $800 000 (on the basis of normal costs), which was increased to a little under $1 000 000 to meet certain requirements of the State Department of Health.

Plans for this work were accepted by the City Council as a part of the agreement of 1920 between the city and the mills, this agreement providing that the Sand Bar Dam and pumping station for the control of the waters

of the South Pond should be built and put in operation as one of the stipulations relative to the taking of the North Pond. The City Council authorized a bond issue of $200 000 in 1920 to begin this work, as well as $75 000 to pay for the North Pond water rights, with the idea of promptly carrying out the terms of this agreement with the mills. Contract plans for the Sand Bar Dam and pumping station were completed in 1920 and bids received for this work in December of that year. Opposition from certain mill interests on South Watuppa Pond toward the carrying out of this project developed early in 1921, with the result that no progress was made during that year.

During the winter of 1921–22 additional legislation transferred the duties of the Quequechan River Commission to the Watuppa Reservoir Commission in order that this work may be promptly carried out and the full control of the North Watuppa Pond obtained by the city, as well as an adequate water supply provided for the mills, and the Reservoir Commission now has these matters in hand.

During 1920–21 the State Department of Health made a general investigation to determine the best method for the joint use of the Lakeville Ponds (a group of large ponds lying some 10 miles northeast of Fall River and including Long Pond, already mentioned) by the towns and cities in that vicinity, reporting on this matter to the Legislature in January, 1922. In brief, this report stated, "That the improvement and protection of these great natural reservoirs can best be secured by united action of the municipalities interested, the cost to be divided proportionately among those interested. This purpose could be effectively carried out, no doubt, by the creation of a water-supply district in this part of the State to include the cities of Fall River, New Bedford and Taunton, and such of the towns in the vicinity of these cities or in the vicinity of the Lakeville Ponds as may desire to join. This would involve the creation of a commission composed of members clothed with sufficient authority for the purpose under a legislative act following the general method adopted at the time of the creation of the Metropolitan Water District. Each municipality would still maintain under such a plan its own individual water system, as is the case in the Metropolitan Water District. To the commission would be left all questions relating to securing, protecting and developing to their full extent the water supplies in these ponds. The commission should be authorized to acquire lands within the watersheds and construct and maintain necessary dams and other appurtenances, together with all drainage works needed for the improvement and maintenance of the water in the ponds, in the best condition. They should also have control of the enforcement of rules for the sanitary protection of the water and the policing of the watersheds and ponds and the location of al intakes or connections with the ponds."

As part of this report, legislation was recommended and given long and serious consideration by the legislative Water Supply Committee and

the various cities and towns interested in the matter. Fall River joined in urging this measure as first presented, which contemplated the utilization of the entire group of ponds under the control of such a Water District.

At the present time New Bedford utilizes two of the ponds, viz. Great and Little Quittacas Ponds, for its water supply, including a drainage area of about 13 sq. mi. out of a total of some 48 sq. mi. for the entire group of ponds. Taunton, with a pumping station on Assawompsett Pond, uses a relatively small amount of the yield of that pond.

In the course of the hearings before the Water Supply Committee it developed that New Bedford did not wish to have the portion of these ponds, viz. Great and Little Quittacas, now controlled by it included in the Water District, and as this involved a much less satisfactory use of the pond system as a whole, as well as materially greater cost to the city of Fall River, the latter has opposed any such sub-division of this pond system.

Essentials regarding area, capacity and the probable safe yield of the Lakeville Pond system appear in the following table taken from the report by the writer on Additional Water Supply for Fall River, dated July 14, 1917: —

PROBABLE SAFE YIELD OF LAKEVILLE PONDS

Pond or Drainage Area.	Drainage Area Sq. Mi.	Per Cent. Water and Swamp Area.	Storage Capacity Assumed.		Safe Yield.	
			Mil. Gals.		Mil. Gals. Per Day Per Sq. Mi.	Total Mil. Gals. Per Day.
			Total.	Per Sq. Mi.		
Long Pond raised 2 ft. El. 49–54	22.3	13.5	3 100	140	0.63	14.0
Assawompsett Pond ..	12.8	33.5	4 300	335	0.68	8.7
Quittacas Ponds	12.8	17.5	3 200	250	0.74	9.5
Snipatuit Pond	6.8	17.5	1 250	184	0.68	4.6
Total, *not* including Snipatuit	47.9	23	10 600	223	0.68	32.2
Total, including Snipatuit	54.7	23	11 850	250	0.68	36.8

In the foregoing table draft to a depth of 5 ft. was assumed for all but the Quittacas Ponds, which were assumed at 7 ft. An additional 2 ft. on top of Long Pond (or a draft from El. 49 to El. 56) would add about 1 500 million gallons of storage capacity, making a total safe yield of about 35 million gallons per day, based upon the yield of the Sudbury River 1879-84, which stream shows about the same yield as the Lakeville Ponds, according to measurements of flow from the latter made by the late Freeman C. Coffin, from December, 1894 to November, 1897.

The report by the State Department of Health of January, 1922 (p. 228) gives the total storage capacity at about 21.3 billion gallons, which evidently corresponds to a much greater draft upon all the ponds. The conclusion in regard to safe yield of 42 million gallons in this report appears reasonable, however, in view of storage possibilities.

Reference to the foregoing table indicates that nearly half of the yield of this pond system comes from Long Pond and its drainage area. The waters of Long Pond and its tributary streams are, however, relatively high in color and must be stored for a very considerable period of time in the lake system to be desirable for use. The manner in which New Bedford has developed its supply is indicative of the best use of this pond system, and the fuller development of the system by cities lying southerly, like New Bedford and Fall River, would naturally be by taking water from Little Quittacas Pond, just as New Bedford has done, thus providing that the highly colored waters of Long Pond before use must travel many miles around and through Assawompsett Pond, thus lowering the color content to a small amount.

The manner is which Fall River has planned to utilize the Lakeville Ponds as an additional supply is shown on the accompanying map, (Fig. 8), and includes a pumping station on Little Quittacas Pond, with pipe line leading to a large distribution reservoir on Copecut Hill, a couple of miles easterly from North Watuppa Pond. Further details of this proposed reservoir will be given later. As a part of the additional water supply system, it will provide a means for the use of the Lakeville Ponds water by one pumping, as the new reservoir will be somewhat higher in level than the present tanks or standpipes in the city. Any method of using the waters of Long Pond directly by pumping them into North Watuppa Pond and storing them there to lower the color content would involve pumping water over the divide in the general vicinity of Mill Brook, a total of about 150 ft. and then a repumping later at the main pumping station on North Watuppa Pond.

It would be possible for Fall River to locate its pumping station on Assawompsett Pond and obtain there water of suitable color content. It is obvious, however, that this would involve some three miles additional length of pipe line, at greater first cost, as well as increased cost of maintenance and pumping, without any corresponding benefit to any one. Furthermore, to get the best results from storage operation, of increasing importance as the water demands of this district grow, these ponds should be dealt with as a unit.

New Bedford has shown great foresight in planning its water supply from the Quittacas Ponds and should be fully compensated for what she has already done in dedicating a considerable part of this pond system to municipal water supply use. The consumption of water in New Bedford is rapidly increasing, however, being now in the vicinity of 10 million gallons per day, or not far from the safe yield of the two Quittacas Ponds.

The city must therefore soon take additional water from the pond system and is therefore vitally interested in the adequate control of all these ponds under a water district.

Legislation is still pending upon this important matter and it is the

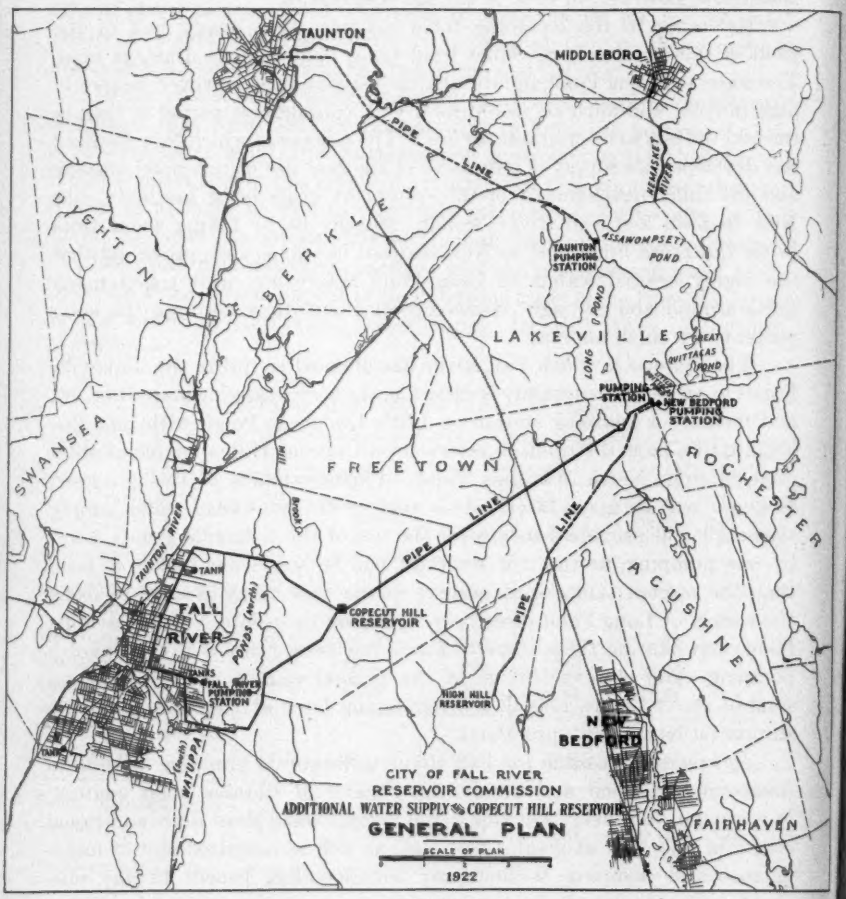


FIG. 8.

hope of Fall River that, if possible, the full and comprehensive use of this pond system may be reached.

Legislation was obtained during the winter of 1921–22 covering the matter of Copecut Hill Reservoir, as well as necessary pipe line connection with the city from this reservoir, and plans are now being prepared for this work. At the present time test pits are being dug at different sites on the hill and information obtained to use as a guide in determining the best

method of construction of a reservoir and its probable cost. A large reservoir holding from a week to ten day's supply of water is contemplated at an elevation somewhat in excess of the level of the present tanks or standpipes, viz. El. 305. As far as the investigations have proceeded it appears that a reservoir can be obtained at a level as high as El. 340, if desired, and that this will probably be of earth embankment type, constructed partly in excavation, partly in fill, with concrete lining.

The construction of an adequate distribution reservoir has been under consideration for many years, as the combined capacity of the four present tanks is only about five million gallons or less than a day's average use of water. There is no available site for such a reservoir within city limits — the highest points reaching only about to El. 260. Copecut Hill is at a considerable distance from the city and will hence require a large expense for connecting pipe mains. On the other hand, certain districts of the city, at about El. 200 or above, where pressures at present are low and unsatisfactory, will be materially and directly benefited by these pipe lines. Furthermore, a reservoir on Copecut Hill fits admirably into the proposed Lakeville Ponds additional supply, by saving an extra pumping of water as already noted.

The cost of the Lakeville additional supply and the Copecut Hill Reservoir and its connections will probably be in the vicinity of $2 000 000, of which approximately $1 500 000 represents the cost of the reservoir and its connections, etc., and the remaining $500 000 the cost of pumping station, pipe line, etc., from Little Quittacas Pond. (If the latter pond is not available, the cost will be materially increased.) Added to this cost will be the proportion which Fall River must pay for the joint use of the Lakeville Ponds with other municipalities, which will add a considerable further amount to the cost of this project.

It is likely that the complete program of additional water supply for Fall River may involve an expenditure of as much as $2 500 000. While this at first glance appears to be a large amount, when compared with the cost of such projects in other cities it is seen to be reasonable. It is, in fact, just about what the New Bedford supply from Quittacas Ponds has cost, including the High Hill Reservoir and its connections with the city. The city of Providence (approximately double the size of Fall River) is spending in excess of $10 000 000 for its new water supply, the contract for the main dam alone at the new Scituate Reservoir totalling about $3 500 000.

The cities of Fall River, New Bedford and Taunton and neighboring towns are indeed fortunate in being located near such a large supply of good water as is afforded by the Lakeville Ponds system, which will provide for their water supply needs for many years, if properly conserved and controlled. Contrast with this the situation with the cities of Lawrence, Haverhill, etc., in the Merrimac Valley, now being studied by the State Department of Health, where additional water supply needs are already

urgent and the difficulties of meeting these adequately are very considerable.

In carrying out the work described at Fall River up to 1917 Mr. Arthur L. Shaw was Resident Engineer, to whom much credit is due for the results achieved — particularly in the construction of the intercepting drain. The success of this latter piece of work was also largely due to excellent construction on the part of the contractor, the Hanscom Construction Co. of Boston, who, at some loss, executed this work in a first-class manner. Since 1917 Mr. John Brown has been Resident Engineer in direct charge of both the water supply and river improvement work. The writer has acted as Consulting Engineer for the Watuppa Reservoir Commission since 1914 and for the Quequechan River Improvement since 1916.

FALL RIVER INTERCEPTING DRAIN — COST DATA 1915–16.

COST PER LINEAR FEET FOR DIFFERENT SECTIONS OF DIAMETER.

6 ft. open section (1470 lin. ft.)						
Concrete	0.427	cu. yd.	@	$9.50	=	$4.06
Reinforced steel	40.64	lb.	@	0.023	=	0.95
Excavation	2.7	cu. yd.	@	0.85	=	2.30
TOTAL						$7.31
8 ft. open section (2600 lin. ft.)						
Concrete	0.458	cu. yd.	@	$9.50	=	$4.35
Reinforced steel	55.31	lb.	@	0.023	=	1.29
Excavation	4.1	cu. yd.	@	0.85	=	3.49
TOTAL						$9.13
10 ft. open section (5608 lin. ft.)						
Concrete	0.505	cu. yd.	@	$9.50	=	$4.80
Reinforced steel	59.50	lb.	@	0.023	=	1.39
Excavation	5.4	cu. yd.	@	0.85	=	4.60
TOTAL						$10.79
6 ft. covered section (154 lin. ft.)						
Concrete	0.536	cu. yd.	@	$9.50	=	$5.10
Reinforced steel	72.46	lb.	@	0.023	=	1.70
Excavation	1.5	cu. yd.	@	0.85	=	1.27
TOTAL						$8.07
10 ft. covered section (2312 lin. ft.)						
Concrete	1.00	cu. yd.	@	$9.50	=	$9.50
Reinforced steel	145.41	lb.	@	0.023	=	3.41
Excavation	3.7	cu. yd.	@	0.85	=	3.14
TOTAL						$16.05

In the foregoing tabulation costs as given are approximate actual costs, not contract prices. Unit costs are, however, for the work as a whole and are not available in segregated form for the various individual sections of drain. Rock excavation is *not* included.

The *unit cost of concrete* (7 618 cu. yd.) was made up as follows:

Labor, teaming, insurance, etc.	$4.27	
Machinery, power and general	0.93	
Lumber for forms, etc.	0.25	
Sand, $0.66 and Stone, $1.39	2.05	
Cement	2.00	
TOTAL	$9.50	per cu. yd.

The cost of forms (in place and removed) — made of wood, for a total area of about 280,000 sq. ft. was about eight cents per sq. foot.

The *unit cost of earth excavation* (58,500 cu. yd.), including refill, was as follows: —

Clearing and burning	$0.02	
Stripping and storing loam	0.17	
Excavating other earth	0.47	
Backfill, etc.	0.16	
Machinery, pumps and miscellaneous	0.03	
TOTAL	$0.85	per cu. yd.

Rock excavation, not included in the costs previously given for different sections of the drain, totalled about 6700 cu. yd. for the total length of concrete section of about 12,144 ft., or just about 10 per cent. of the total excavation. Of this rock practically one-third was boulders of one-half cu. yd. or more, the remainder ledge.

The cost of rock excavation was about $19 500, which averages $1.60 per linear foot of drain and about $2.90 per cu. yd.

Base costs for labor and material were:

Ordinary labor	$1.80	per day of 9 hours
Single teams and driver	3.75	" " " 9 "
Double teams and driver	5.50	" " " 9 "
Cement	$1.20	per bbl.
Sand	1.50	" cu. yd.
Crushed stone	1.58	" cu. yd.
Dynamite	0.20	" lb.
Reinforced steel	0.023	" lb.

DISCUSSION.

MR. FRANCIS T. KEMBLE.* I would like to inquire what they are doing at the present time in connection with taking care of drainage from those cottages which are shown along the banks in two instances, I think.

MR. GOODNOUGH. All of these watersheds are under the control of the local authorities. They are protected by rules and regulations which are enforced by the Water Boards in each case. They are cared for very carefully as far as my knowledge goes, in both watersheds. There is nothing around the New Bedford supply to do harm in any case, and in Taunton I think the rules are carried out very strictly.

MR. KEMBLE. Are there any cesspools?

MR. GOODNOUGH. The regulations call for no cesspools within 50 ft. of the water, or within 50 ft. of any water course.

MR. ROBERT S. WESTON.† Do those regulations apply to Long Pond as well as to Assawompsett?

MR. GOODNOUGH. No, they do not. We can't even stop bathing in Long Pond. I think that it depends on the judge before whom bathers are taken.

MR. WESTON. What are the relative elevations of High Hill Reservoir and the proposed Copecut Reservoir?

MR. GOODNOUGH. Copecut Reservoir is a great deal higher than High Hill.

MR. CALEB M. SAVILLE.‡ I have been very much interested in both of these descriptions of water supplies, particularly in the data which Mr. Goodnough has so well brought forward with regard to the growth of the population. It seems to me that this is a matter of considerable importance because of its bearing in making up estimates for additional water supplies and for financing them, the relation between the growth of European cities and those in America; whether they are strictly comparable. What Mr. Goodnough has said of the English cities is most interesting and instructive. Of course we must base our estimates of the future growth of population on information of that kind. In America there are comparatively few cities which can be compared after they have reached populations of 150 000 to 200 000 or more because of local environment which inequally affects the growth. Also conditions seem to me vastly different in American cities from those in English cities. England, on account of racial characteristics, perhaps, and again on account of geographical conditions, is in a somewhat different position as to its city growth. You can't get out of England. England is a comparatively small place. The coal mines, which are the basis of the English industry, are located not far from the big centers. The Englishman always moves

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† Consulting Engineer, Boston, Mass.
‡ Chief Engineer, Board of Water Commissioners, Hartford, Conn.

slowly. In America we move more rapidly and so it seems we can not make direct comparison.

This was particularly brought to my attention in considering what the effect will be on some of our Connecticut cities that have now reached a population of perhaps 150 000 or 175 000. Consider the effect of the big movements that are on foot, perhaps this super-power proposition that is now rather agitating us, of bringing the larger industry to the coal mines; or developing power at the coal mines, if you please.

It is desirable, perhaps, to get our industries nearer the source, to get cheaper labor and less transportation difficulties, but large movements of this kind seem bound to affect local growth. That is particularly pertinent, at this time I think, on account of the sale or the transfer of the stock recently, of the American Brass Company, which has large industries in Torrington, Waterbury and Ansonia, to the Anaconda Copper Company. Those industries are practically the life of those Connecticut cities I have mentioned. There is a thought, and it is rather a serious one, that in time the bulk of the product now made by the American Brass Company in those towns will be transferred to the nearer copper fields in Butte for sheet copper and plain bulky materials. What bearing such a movement will have on the growth of those particular Connecticut cities is problematical.

MR. THEODORE L. BRISTOL.* I do not think anyone knows what the result will be in the Naugatuck Valley. When the Anaconda Company bought the American Brass Company they were very careful to state that it would make no difference with the organization, that they intended to keep the mills running and the same people. I think it is some question how this will work out. Probably there will be changes.

I was in the operating manager's office in Ansonia the other day and there was a call for wire drawing dies. It seems the Anaconda Company had placed an order for wire drawing dies to be shipped to Butte and were not getting them fast enough, and they wanted to know if they could borrow some from Ansonia. The dies were immediately sent them from surplus stock. That shows that they are probably transferring a lot of wire drawing to Butte, and I presume they will take care of their western territory at Butte and will eventually establish sheet mills there. The copper business is pretty good now; they are trying to work twenty-four hours a day in Ansonia. It started with the wire mill which has been working twenty-four hours for several months. They have built a new mill in Ansonia, quite a large wire drawing mill. Probably that will not be abandoned. But it all depends upon where the demand comes from.

Of course in all these localities there have been other businesses that are called cutting up shops. They are the people who manufacture the copper into other articles. That will tend to keep the business in this locality which is in the locality of the present brass and copper cutting up shops.

* President Ansonia Conn., Water Co.

Perhaps to show how things may move, I will say that there is another large industry in Ansonia, the Farral Foundry and Machine Company, which has bought quite a large plant in Buffalo because it saved considerable in freight on coal and iron. I think they did that principally for manufacturing rubber mill and wheat rolls to be shipped to Ohio and the West. But it has made no noticeable difference with Ansonia.

PRESIDENT BARBOUR. I was interested in what Mayor Remington told me regarding some statement in a paper which he had recently unearthed about the removal of the textile industry to the South some fifty years ago.

MAYOR W. H. B. REMINGTON. I would be very glad, Mr. President, to say what I said to you about that particular matter.

In 1855 my father was an operative in the Wamsutta Mills here. At that time he purchased a little book which was called "American Cotton," containing more or less details about the cotton business. During the last year I came across that book, and in it found an almost exact reproduction of the argument which has been made within a short time about the removal of the cotton business to the South. That was over fifty years ago, and the cotton mills are still in this section of New England. Of course they have many mills in the South. That led me to think that possibly there might be more or less bugaboo about that suggestion.

TARS, NEW AND OLD.

BY S. R. CHURCH.

[*December, 1922.*]

INTRODUCTORY.

Coal tar is so valuable as the source of many useful materials in chemistry and in engineering, it is of such scientific and commercial importance, that one is compelled to express surprise as well as regret that there is no comprehensive reference book on the subject. I say this with due regard to Lunge's extensive work on coal tar and ammonia, long considered authoritative. In recent editions of this once valuable work no real effort has been made to bring the facts down to date and it is especially deficient as regards American practice. The book contains much wheat and a great deal of chaff and the reader is compelled to sift for himself.

Warnes hand book on coal tar distillation is concise and describes English tar distilling practice quite well, but the author has made no attempt to cover the entire subject and his book is of value to the tar distiller but not to the users of tar products. The same can be said of Kreamer and Spilker's chapter on coal tar in Muspratt's Chemistry (German), and a fairly exhaustive treatise in French by Berthelot, printed in *Revue de Metallurgie.*

In fact the engineer or chemist who desires to use tar products finds the literature pretty barren and indeed many of the scanty references available are inaccurate. For instance in the very useful Lefax tables, the specific gravity of " tar " is given at 1.015. Of course all tar is not coal tar and there may be some variety of wood tar having that specific gravity, but it is to be feared that some will apply this value to coal tar.

Even such a dignified authority as the Encyclopedia Britannica is guilty of this, " The heavier tars contain less benzol than the lighter tars and more fixed carbon, which remains behind when the tars are exhausted of benzol and is a decidedly objectionable constituent." It is no wonder that engineers who have had little actual contact with coal tar find it very difficult to define their requirements when in need of tar products, or that some of the specifications met with are drawn without a real understanding of materials and purposes.

The whole matter of writing specifications for the cruder forms of tar products (meaning creosote oil, road binders, pipe coatings as distinguished from refined products such as phenol or naphthalene) has been surrounded by more than ordinary difficulty. Tars are by-products and

their physical character and composition are determined by conditions existing in the gas retort or coke oven, conditions over which the tar distiller has no control.

The tar distiller has had to take tars as produced, and determine as best he could, by field experience and laboratory research, how to convert them into uniform products suitable for the purpose intended. Looking at the subject from a modern chemical engineering standpoint, it must be admitted that rule of thumb methods prevailed in the tar refinery until about ten years ago. During the past ten years much progress has been made and not only have good workable specifications been developed for the principal tar products; but many improvements and economics have been worked out in the distilling and other refining processes, based on a growing knowledge of the physical constants and composition of the materials dealt with. Time does not permit going into this phase of the subject but it may be mentioned that our researches have included determining the specific heat of tar distillates and residues, the vapor density and molecular weights, latent heat of vaporization, etc. Obviously all of these facts are needed in correctly designing distilling equipment but they are absolutely unavailable in the literature.

The object of this paper is to endeavor to show by some typical and comparative analyses the general range of American tars including coal tars from gas works and coke ovens and water gas tars from petroleum gas oil. These are properly considered together as they comprise the tars dealt with by American tar distillers. We hear of wood tars, blast furnace tars, lignite tars, producer tars, etc., but these are either foreign to this country or to American tar distilling practice.

The best available statistics (Mineral Resources of the U. S. 1920 and 1915) give the tar production as —

	1920		1915
Tar Gallons.	Production.	Sales.	Production.
Coke Oven	360 000 000	174 000 000	140 000 000
Coal Gas	51 000 000	46 000 000	45 000 000
Water Gas	114 000 000	58 000 000	80 000 000

The later figures are no doubt more nearly accurate but the growth in production is apparent, as well as the fact that the increase is largely in tar produced on by-product coke ovens. However, the tar available to the distillers has not changed so largely as to its source, as the total figures indicate, due to the rather wide adoption of tar burning on the part of many of the by-product oven owners.

Methods of Testing Tars.

Before considering the characteristics of different types of American tars it will be useful to illustrate and briefly describe some of the laboratory tests ordinarily made on crude and refined tars and by means of which we identify and classify the crudes and control the consistency of the refined tars and soft pitches.

DISTILLATION TEST.

The apparatus illustrated in Fig. 1 is used for testing crude tar for water and also for distilling tar to pitch and determining the per cent. oil yield. The oil and pitch obtained can be further examined if desired.

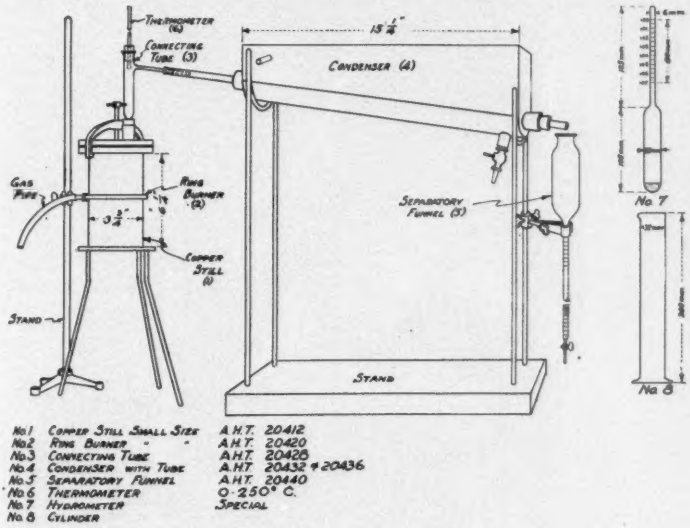

FIG. I — APPARATUS FOR DISTILLATION.

When water only is to be determined

Crude Tar Tests — Water.

Apparatus. Copper still, 6 in. by 3½ in. Ring burner to fit still. Connecting tube. Condenser trough. Condenser tube. Separatory funnel. Thermometer, 0°–250° C. See Fig. I.

Method. Fifty cc. of coal tar naphtha or light oil shall be measured in a 250 cc. graduated cylinder, 200 cc. of the tar to be tested shall be added. The contents shall be transferred to the copper still, the cylinder shall be washed with 100-150 cc. more of naphtha, and the washings added to the contents of the still. The lid and clamp shall be attached, using a paper gasket, and the apparatus set up as shown in Fig. II. The condenser trough shall be filled with water. Heat shall be applied by means of the ring burner, and distillation continued until the vapor temperature has reached 205° C. (401° F.). The distillate shall be collected in the separatory funnel, in which 15 to 20 cc. of benzol have been previously placed. This effects a clean separation of the water and oil. The reading shall be made after twirling the funnel and allowing to settle for a few minutes. The percentage shall be figured by volume.

Precautions. When fresh supplies of naphtha or light oil are obtained, they shall be tested to determine freedom from water.

Accuracy. One-tenth of 1 per cent.

Note. For works control an iron still of the same size and shape as the copper still specified above may be used. Some laboratories omit

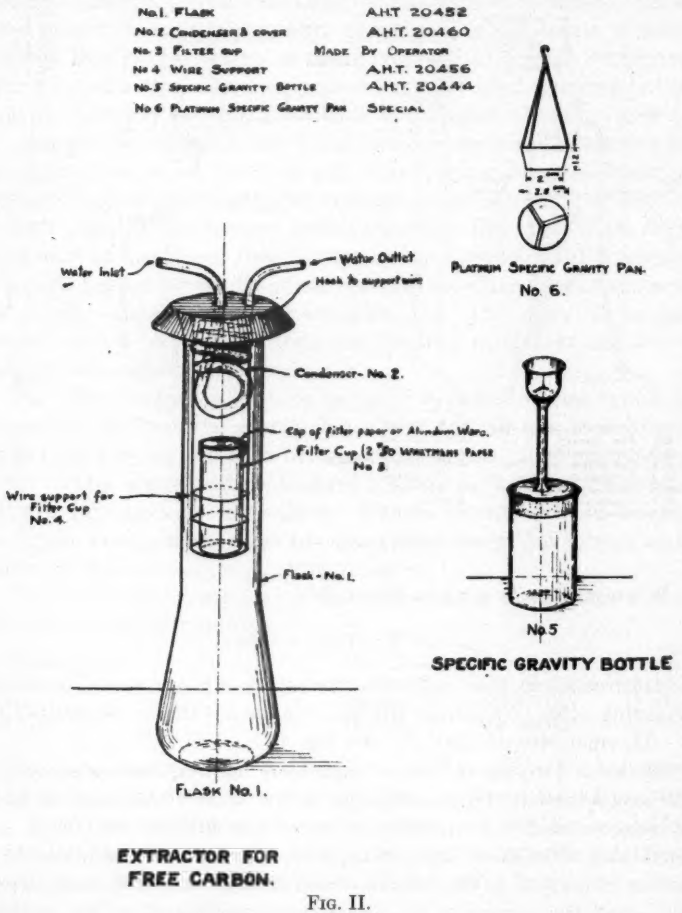
No. 1. Flask A.H.T. 20452
No. 2 Condenser & cover A.H.T. 20460
No. 3 Filter cup Made By Operator
No. 4 Wire Support A.H.T. 20456
No. 5 Specific Gravity Bottle A.H.T. 20444
No. 6 Platinum Specific Gravity Pan Special
Platinum Specific Gravity Pan. No. 6.
Water Inlet
Water Outlet
Hook to support wire
Condenser- No. 2.
Cap of filter paper or Alundum Ware.
Filter Cup (2 "SD Whatmans Paper No. 3
Wire support for Filter Cup No. 4.
Flask - No. 1.
Flask No. 1.
No. 5
Specific Gravity Bottle
Extractor for Free Carbon.

Fig. II.

the use of the thermometer and judge when the water is off by the appearance of the distillate. These variations must never be applied where check test is required or in case of dispute.

Dehydration (Preparation of Dry Tar) — Apparatus.

Method. About three hundred to four hundred cc. of tar shall be placed in the copper still without the addition of naphtha. The apparatus

shall be set up as in Fig. I, except that an ungraduated separatory funnel may replace the special graduated one. The distillation shall be carried on cautiously at first to prevent foaming and continued until the vapor temperature reaches 170° C. (338° F.). Any oil which has distilled over shall be separated from the water (warming sufficiently, if crystals are present, to insure their solution). This separated oil shall be thoroughly mixed back into the residual tar in the still, after the latter has cooled to a moderate temperature. The dehydrated tar shall be then transferred to a suitable container.

Note. A temperature of 170° is used because this is sufficiently high to expel all water from the still. In test I a higher temperature is used to insure flushing out the condenser tube.

When oil yield to a given temperature, or to a certain melting point of pitch, is desired, the addition of naphtha is of course omitted.

The stills can be had in a larger size fitted with a convenient draw-off cock for sampling the pitch and emptying the contents of the still.

EXTRACTION WITH BENZOL.

Crude tar, if it contains not more than about 5 per cent. of water may be tested but for accurate results the tar should first be dehydrated in the distillation apparatus heretofore described.

The test as described is also applicable to refined tars and pitches.

Insoluble in Benzol (Free Carbon).

Apparatus. Extraction flask. Condenser and cover, wire support. See Fig. II. Extraction thimble (prepared by operator).* Cap of filter paper or alundum. The latter are 30 mm. inside diameter by 14 mm. high. Balance: an ordinary analytical balance accurate to 0.0005 g. Steam bath, water bath, or electric hot plate. Beakers, 100 cc. Carbon filter tubes, 37 mm. size. Weighing bottle, 32 mm. by 70 mm. Camel's hair brush, 14 mm.

Method. Tar dried as described under Test I shall be used. After drying, it shall be passed hot through a 30-mesh sieve to remove foreign substances. The amount of tar to be taken for test depends on the content of insoluble material and shall be:

Less than 5 per cent., 10g.
5 per cent. to 20 per cent., 5 g.
Above 20 per cent., 3g.

If the content of insoluble material cannot be approximated, the larger amount shall be taken. The amount shall be weighed into a 100 cc. beaker

*These shall be made of Whatman No. 50 filter paper. To make a cup, two 15 cm. circles shall be taken and one cut down to a diameter of 14 cm. A round stick about 1 in. in diameter shall be used as a form. The stick shall be placed in the center of the circles of filter paper, the smaller inside, and the papers folded symmetrically around the stick to form a cup about 2½ in. long. A little practice enables the operator to make these evenly and quickly. After being made they shall be soaked in benzol to remove grease due to handling, drained, dried in a steam oven at 97° to 100° C., cooled in a desiccator and kept there until used.

and digested with pure toluol at 90° to 100° C. for a period of *not over thirty minutes*. The solution shall be stirred to insure complete digestion. A filter cup prepared as described shall be weighed in a weighing bottle and placed in a filter tube supported over a beaker or flask. The thimble shall be wet with toluol and the toluol-tar mixture decanted through the filter. The beaker shall be washed with toluol until clean, using the camel's hair brush as a policeman to detach solid particles adhering to the beaker. All washings shall be passed through the filter cup. The filter cup shall then be given a washing with pure benzol and allowed to drain. The cap shall then be placed on the cup and the whole placed in the extraction apparatus and extracted with pure benzol until the descending benzol is completely colorless. The cup shall then be removed, the cap taken off, and the cup dried at 97° to 100° C. After drying, it shall be allowed to cool in a desiccator and weighed in the weighing bottle. The increase in weight represents matter insoluble in benzol.

Precaution. If the first filtrate shows evidence of insoluble matter, it should be refiltered. The 30-min. period allowed for digestion must not be exceeded.

Accuracy. Five per cent. of insoluble matter present. In other words, with 20 per cent. of " free carbon " present, a 1 per cent. accuracy may be expected.

MELTING POINT OF PITCH.

This method is universally used by producers and consumers of tar pitches to determine its consistency and is applicable to the range of pitches from those which will hardly retain form at normal temperature (about one hundred degrees F. melting point) to those which can hardly be " chewed," or indented with the finger nail (about one hundred seventy degrees F. melting point.)

Test D6 — Water Melting Point.

Apparatus. See Fig. III.

Pitch mould. Hook made of No. 12 B. and S. gage copper wire (diam. 0.0808 in.). Beaker, 600 cc., Griffin's low form.

Thermometer: The thermometer shall conform to the following specifications:

Total length	370 to 400 mm.
Diameter	6.5 to 7.5 mm.
Bulb length	Not over 14 mm.
Bulb diameter	4.5 to 5.5 mm.

The scale shall start not less than 75 mm. above the bottom of the bulb and extend over a distance of 240 to 270 mm. The graduations shall be from 0° to 80° C. in $^1/_5$° C. and shall be clear cut and distinct.

The thermometer shall be correct to 0.25° C. as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the Bureau of Standards.

The thermometer shall be furnished with an expansion chamber at the top and have a ring for attaching tags. It shall be made of a suitable quality of glass and so annealed as not to change its readings under conditions of use.

Methods. (*a*) *Pitches having melting points between 43°C. and 77°C., (110° to 170°.).* A clean shaped half-inch cube of pitch shall be formed

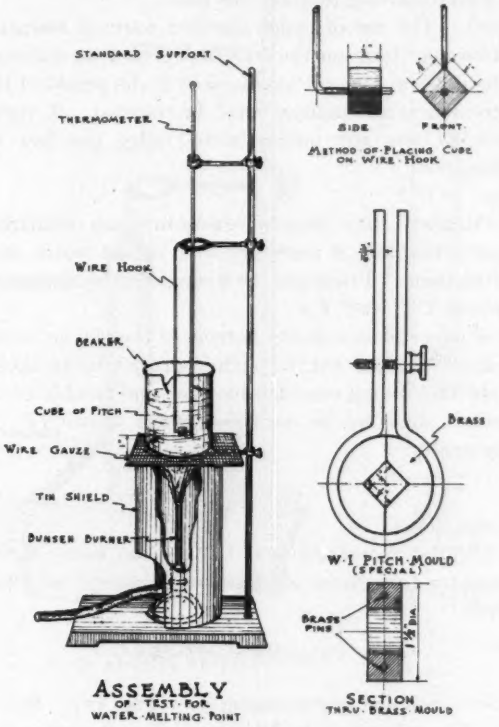

FIG. III.

in the mould and placed on the hook or wire (see Fig. III for detail of method of placing the cube on the wire). The apparatus shall be assembled as shown in Fig. III, placing 400 cc. of freshly-boiled distilled water at 15.5° C. in the beaker.

The thermometer shall be placed so that the bottom of the bulb is level with the bottom of the cube of pitch and shall be immediately contiguous to, but not touching, the cube.

The pitch cube shall be suspended so that its bottom is 1 in. above the bottom of the beaker and allowed to remain in the water at 15.5° C. for 5 min. before starting the test. Heat shall then be applied in such a manner that the temperature of the water is raised 5°C. (9° F.) each

minute. The temperature recorded by the thermometer at the instant the pitch touches the bottom of the beaker shall be reported as the melting point.

(*b*) *Pitches having melting points below 43° C. (100° F.).* These shall be tested exactly as under *a*, except that the water at the start shall be 4° C. (40° F.) and the cube shall be allowed to remain 5 min. at this temperature before starting to apply the heat.

Precautions. The use of boiled distilled water is essential, as otherwise air bubbles may form on the cube and retard its sinking. The rate of rise must be uniform and not averaged over the period of the test. All tests where the rise is not uniform shall be rejected. A variation of not more than ±0.5° C. for any minute period after the first three is the maximum allowable.

Accuracy. ±1° F.

Notes. Pitches of the *a* range of consistency can ordinarily be molded at room temperature, but, if necessary, cold or hot water can be used to harden or soften them. Pitches of the *b* range can be conveniently formed in water of about 4° C. (40° F.).

A sheet of paper placed on the bottom of the 600 cc. beaker and conveniently weighted will prevent the pitch from sticking to the beaker when it drops off, thereby saving considerable time and trouble in cleaning.

This method shall not be used on pitches above 77° C. (170° F.), water-melting point.

CONSISTENCY.

(Schutte penetrometer).

This is adaptive to refined tars that are too heavy for the ordinary orifice viscosimeter test except at high temperatures, and too soft to be classed as pitch.

Consistency (Schutte).

Apparatus. Schutte penetrometer (see Fig. IV). Stop watch.

Method. The collar shall be filled by placing it upon a flat tin roofing disk which has been coated with a thin film of vaseline and pouring an excess of material into the collar. After cooling and contraction the excess material shall be cut off level with the upper edge of the plug by means of a heated knife blade. The collar shall be then immersed in water of the required temperature and left at that temperature for 15 min. The collar with roofing disk attached shall be screwed into the tube while the tube is in position. The water bath shall just cover the shoulder of the tube. The tube shall be filled with water of the required temperature and the roofing disk removed by slipping it sideways. The time (measured by a stop watch) from the slipping off of the disk to the sudden drop of the disk to the sudden drop of the water in the tube, shall be noted and reported in seconds.

Precautions. Take extreme care to keep the water bath within 0.5° F. of the required temperature.

(Float Test).

This applies to the same class of material as mentioned under (4). Recently, Committee D4, A.S.T.M. have issued new detailed specifica-

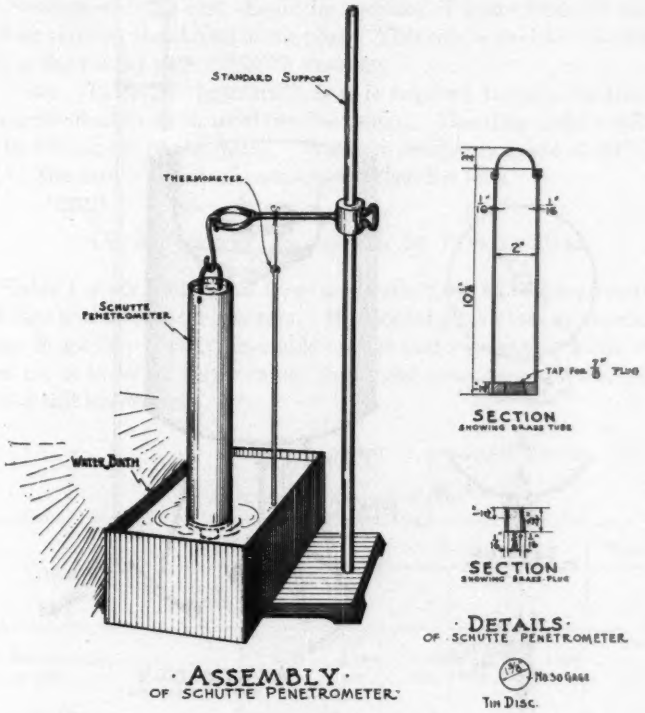

FIG. IV.

tions for the float instrument and these differ somewhat from the dimensions illustrated. The A.S.T.M. specifications should be adhered to in order to obtain consistent results.

CONSISTENCY (Float)*

Apparatus. Float tester (see Fig. V). Brass plate, 5 x 8 cm. Stop watch.

Method. The brass collar shall be placed with the small end down on the brass plate which should be previously amalgamated with mercury by rubbing it first with a dilute solution of a mercury salt and then with

* Adapted from Bulletin 314, Office of Public Roads.

metallic mercury. Sufficient of the material to be tested shall then be melted in a suitable container, care being taken to prevent loss by volatilization or formation of air bubbles. The material shall then be poured into the collar in a thin stream until slightly more than level with the top. The surplus shall be removed, after cooling to room temperature, by means

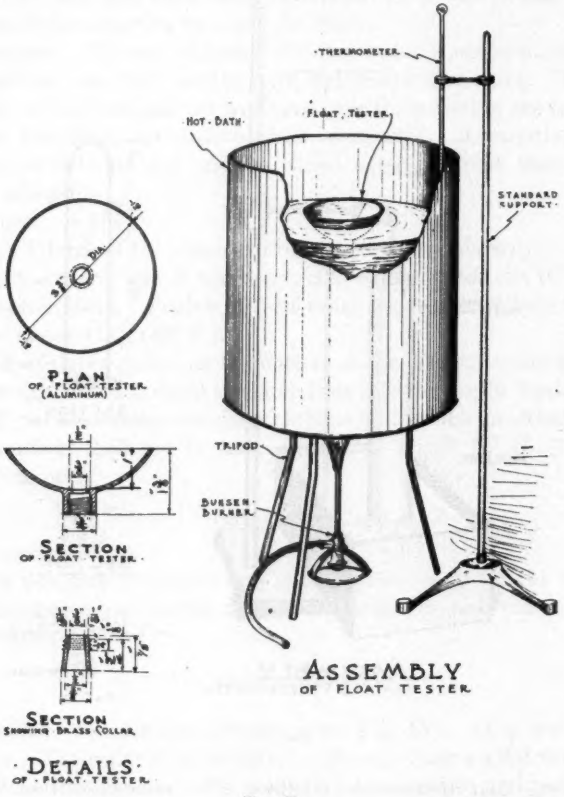

FIG. V.

of a steel spatula, the blade of which has been slightly heated. The collar with plate attached shall then be placed in water at 5° C. and allowed to remain at that temperature for at least 15 minutes. A suitable water bath shall be filled ¾ full of water, placed over a burner and brought to the temperature at which it is desired to make the test. This temperature shall not be allowed to vary during the test more than 0.5° C. from the required point. The brass plate shall be removed from the collar and the latter with contents shall be screwed into the aluminum float, which shall then be immediately floated on the carefully regulated warm bath. As the

plug of bituminous material becomes warm and fluid, it is gradually forced upward and out of the collar until the entrance of water causes the collar to sink. Unless otherwise specified, the time in seconds (noted by a stop watch) from placing the float in water to the *time the water breaks through the material* shall be reported as the consistency of the material.

Precautions. No test should be recorded if water finds its way into the float through the thread of the plug. This can be avoided by thorougly coating the thread with grease or vaseline.

Notes. In certain specifications it is required to take the time from placing the float in water until the float sinks. This may make a difference of 5 to 10 seconds in the result. Tests are ordinarily made at 50° C. At 100° C. the test is not at all sensitive for distilled tars.

Characteristic Properties of Typical Tars.

Table I gives analyses of three gas works tars, three by-product coke oven tars and two water gas tars. Horizontal retort tars as shown to be highest in specific gravity, insoluble matter and viscosity — while vertical retort tar is lower in those values than coke oven tars. Water gas tars fall in a still lower range.

TABLE I.

Analysis of Typical Tars.

Origin.	Gas Retort.			Coke Oven.			Water Gas.	
	Horizontal.	Horizontal.	Vertical.					
Specific gravity crude	.....	1.198	1.180	1.179	1.172	1.176	.....	1.110
Water, per cent.	.....	5.3	1.2	1.6	4.6	2.8	.....	4.9
Dry Tar.								
Specific gravity 15.5° C.	1.266	1.222	1.166	1.181	1.188	1.193	1.083	1.121
Insoluble in benzol	28.9	21.1	6.0	6.8	9.2	4.7	0.1	2.6
Ash, per cent.	.....	0.2	.....	0.03	0.01	0.2	0.1	0.1
Viscosity 50°-C sec.	.....	.....	128	217	407	.....	80	.....
Viscosity 115°-C sec.	300+	67	30	34	42	38	25	42
Oil to soft pitch	13.2	21.0	26.5	24.3	29.6	30.7	43	.....

Table II shows the general range of each class of tars, i.e. minimum and maximum limits of the different properties. These will be later referred to in discussing their relation to the application of the various tars in pipe coating.

TABLE II.

PROPERTY OF COAL TARS.

Properties.	Gas-Works Coal Tar.			Coke Oven Tars.
	Horizontal Retorts.	Inclined Retorts.	Vertical Retorts.	
Specific gravity at 60° F.	1.20 to 1.25	1.10 to 1.20	1.10 to 1.15	1.17 to 1.22
Viscosity	High	Medium	Low	Low
Free carbon (insoluble in benzol) per cent	18 to 30	10 to 20	0.4 to 5	2 to 12
Distillate, per cent. by volume, on distilling to a medium grade of pitch	20 to 30	25 to 35	30 to 40	25 to 35
Per cent. of pitch by volume (medium pitch) plus losses .	70 to 80	65 to 75	60 to 70	65 to 75
Tar acids, per cent.	1.6 to 3	3 to 5	7 to 8	0.4 to 2.5

The graph (Fig. VI) illustrates the general range of the distillates from each class of tars, in specific gravity.

Specific gravity is undoubtedly one of the most valuable indentification methods on all hydro-carbon materials, especially in connection with the fractional distillation. On the other hand the strict application of test to crudely taken fractions often leads to misjudgment and difficulty. When more fully developed the test has great possibilities both in control and research work.

TABLE III.

SERIES OF SAMPLES OF REFINED TAR MADE FROM SAME RAW TAR.

Sample No.	Free carbon Percentages.	Distillation Total to 315° C.	Melting Point ° F.	Schutte Penetrometer Sec. at ° F.	Viscosity Engler 100 cc. at 100° C. Sec.	Float Test at 50° C. Sec.
5	12.1	21.8	.....	29 40	94	34
7	12.0	19.2	.....	108 40	127	38
8	14.0	16.4	.....	114 50	159	58
9	14.4	14.9	86.9	85 60	208	75
10	17.2	12.7	99.7	90 70	335	110
11	18.2	10.4	108.7	88 80	431	170

Table III shows an interesting comparison of the values of different methods of testing the consistency of refined tars and soft pitches. There is no one method that can be applied throughout the range from a crude or dehydrated thin tar to a pitch suitable for say road binder or roofing. As we go from liquid to semi-solid and solid mobile materials, the limits of the orifice viscosimeter are soon passed and hybrid methods such as the "float test" which determines neither viscosity or melting point but a

mixture of both qualities, seems to be the only feasible method for use through a certain range of consistency. These methods all involve time and temperature; there is, however, an important distinction between melting point, in which the temperature is raised at a fixed rate to the point at which

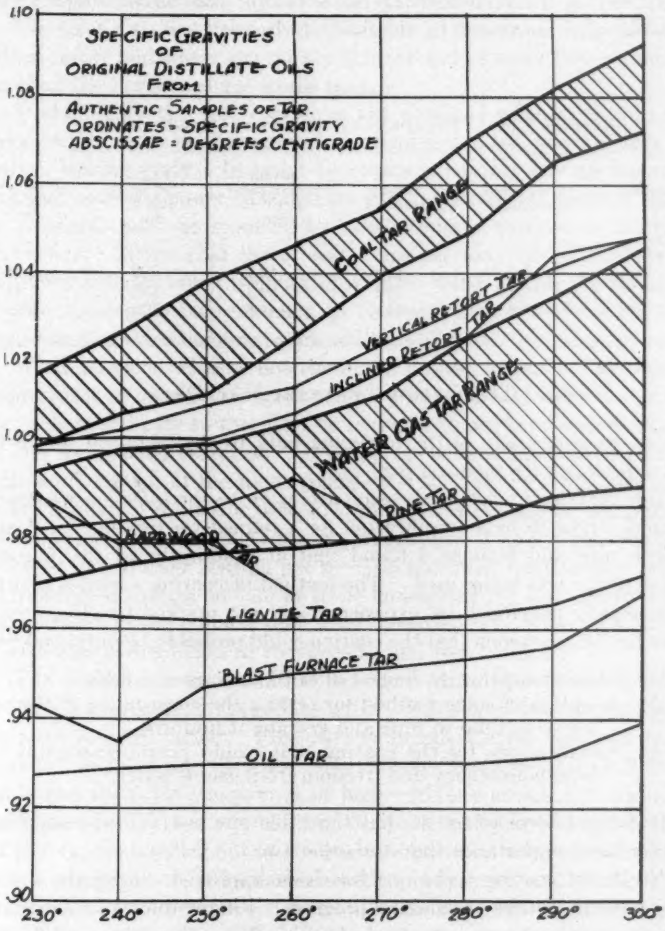

FIG. VI.

the material becomes so soft that its cohesion no longer supports it, and the float, penetrometer and viscosity tests wherein the temperature is fixed and the time required for the material to lose cohesion is the determinable point. Therefore in choosing a method for testing the consistency of semi-solid bitumens, regard must be had not only to the range of limitations of the method's adaptability, but to the question whether it is desired to

determine the behavior of the material at a certain temperature, or the temperature at which the material will behave in a certain way.

A critical study of Table IV would take us far into theoretical speculation, but it is clearly shown that materials of widely varying free carbon content having the same melting point, exhibit varying consistency characteristics when measured by the float or viscosity test.

TABLE IV.

REFINED TARS — RELATION OF VISCOSITY TO CARBON CONTENT.

Sample No.	Free carbon Percentages.	Melting point ° F.	Schutte penetrometer at 80° F. Sec.	Engler 100 cc. at 212° F. Sec.	Float test 212° F. Sec.
1	1.4	110	42.2	302	158
2	14.5	109	80.1	298	192
3	39.6 •	112	144.9	739	337

APPLICATION OF ANALYTICAL DATA.

Can we apply any of the foregoing data to the technical use of tars and tar products for pipe coating?

Ten years ago I first gave some attention to the question whether or not there ought to be a specification for a refined tar product for coating cast-iron pipe and fittings; I found that at practically all the foundries crude coal tar was being used. The method of coating varied somewhat, it was usually developed by experience and not marked by close control. I came to the conclusion that the coating could probably be improved by —

(*a*) Closer temperature control of both castings and bath.
(*b*) Adoption of some method for testing the consistency of the coating from time to time and keeping it uniform.
(*c*) Specifications for the coating that would insure reasonably uniform consistency and freedom from excess water.

It did not seem to me at that time that the last named requirement was of greater importance than the other two.

No doubt coating technique has been improved during the last ten years; most industries are making progress. I know that your Association has been giving attention to the problem and that tentative specifications for pitch for pipe coating are under consideration.

You may ask — Is pitch a better material for coating pipe than crude coal tar? If so what should be the melting point of the pitch? What is the meaning or significance of " free carbon " in tars and pitches? Should the origin of the tar be specified, that is — gas works, coke oven, etc?

The tars first used for coating pipe were necessarily horizontal gas works coal tars, as the by-product oven, the vertical gas retort and the

carbureted water gas process had not been introduced. In the early days of gas-making fire clay retorts were used and the first important change in the character of coal tar occured when fire clay was replaced by silica retorts. With the latter higher heats were employed and tar was produced of very high viscosity and high free carbon content.

We have already shown that the newer types of tar, i.e., coke oven, vertical retort and water gas tar are thinner and of lower free carbon content than the horizontal gas works tars.

Undoubtedly the best coating is not obtained when very thin tar is used — crude water gas tar or crude vertical retort tar makes a very poor coating, lacking body. In order to obtain a coating having the consistency and covering power of a medium gas works coal tar, most of the tars now available must be modified by distillation, or reduced to the proper consistency. Either coal tar or water gas tar may be reduced to any desired consistency but it is doubtful whether water gas tar should be used for pipe coating as its resistance to chemical attack and its life under conditions of service have not been well established.

What happens when a hot casting is dipped in tar? The object of the process is to obtain a thin but complete coating that will dry in a short time, adhere strongly to the pipe, be resistant to abrasion and finally protect the metal from corrosion. If crude tar is used the heat is sufficient to drive off enough of the more volatile oils so that the remaining film or coating is pitch. If pitch is used to start with, either higher temperatures must be employed or a thicker coating will result. I do not believe there is any merit in a thicker coating per se — on the other hand a very thin tar may produce a coating so thin as to be non-protective and unduly brittle. I am inclined to the opinion that what is needed is a refined, i.e. distilled tar with reasonable limits as to viscosity and free carbon.

The viscosity limits should be specified at an elevated temperature, say 100° C. approaching that of the bath. What does free carbon signify? The term is a misnomer. Free carbon means matter insoluble on hot extraction with benzol. It is not "free carbon," but a mixture of difficultly soluble and insoluble compounds of high carbon content, but containing some hydrogen. Tar is a product of destructive distillation which means that the vapors distilled out of the coal are partially decomposed and the result is a mixture of hydro-carbons with some oxygen and nitrogen compounds which were not present as such in the coal, but are formed in the retort; " Free Carbon " so called is an index to the amount of decomposition that occurs. Tar obtained from coal under conditions unsuitable for decomposition, for example, under high vacuum with rapid removal from the retort would be entirely different from our commercial tar. It would contain a lot of paraffin compounds and phenols and would be thin, and oily with a very low pitch content.

Free carbon in the specification is simply a means of providing for tars that have been produced at neither too low nor too high heats. Lack

of it indicates a thin tar of inferior covering capacity, too much, a thick material difficult to handle and settling out in the treating vessel or bath.

I do not believe apart from specifying that the tar should be obtained from the carbonization of bituminous coal, that its origin need be specified if the proper limits for consistency and free carbon are arrived at. Uniformity is what is wanted and it is the tar distiller's job to produce that uniformity by selecting and combining his tars, and processing the mixture to obtain the desired product.

The tar producer cannot insure this, and while tar from one source may run very uniform for a long time it may and in fact often does change profoundly without any warning as the requirements of coke and gas vary.

It has been the history of material specifications that as we approach perfection the requirements for the finished product become more important than the question of where the raw material originated.

Discussion.

Mr. H. T. Miller.* We know that the wide range between the melting point and the brittle point of asphalt is very large, but in my experience the range between the melting point and the brittle point of coal tar has been very narrow. Has Mr. Church found any wider range on coal tar between those two points?

Mr. Church. There is no doubt but that we are seeking for a material which combines the good qualities of coal tar and those of asphalt. The acknowledged resistance of coal tar to chemical reaction, its long service, its absolute waterproofing capacity, with the physical properties, the gentleman speaks of, that asphalt possesses—that is, lack of susceptibility to temperature changes — unfortunately, that animal has not been discovered yet. It seems there is something inherently different in the composition of materials which have a low susceptibility factor. The reason that they have the low susceptibility factor — that is, that they resist temperature changes — may be allied with the reason why they do not resist chemical reactions as well as coal tars. In other words, they may be more readily oxidizable. There are some indications that way. But I can't say that we have really produced coal tars having a very markedly improved range of resistance to temperature changes, although by selection and by proper refining we can, of course, accomplish something in that direction. In other words, some tars are better in that respect than others.

I am afraid that is not a very satisfactory reply to the question, but it is the only one I can make at the present time.

President Barbour. Is there any possibility of combining some per cent. of asphalt with the tars in order to widen the temperature differential?

* Of National Tube Co.

MR. CHURCH. That has been tried, and it has been done to some extent. We have had specifications in one or two cities for years for a mixture of coal tar, pitch and asphalt for paving-block filler. We have tried it ourselves and endeavored to improve some of our roofing products. I can't say that the results have been extremely encouraging. There is a limit to the percentage of asphalt that can be mixed with coal tar — that is, from the standpoint of getting a homogeneous compound. Some asphalts can be mixed in greater proportion than others. Those having important aromatic compounds can be used to a larger extent than those which are high in paraffin compounds. It is worse than useless to mix an asphalt obtained from the reduction of a paraffin base oil, with coal tar, because you only get a mess, but a certain proportion of a properly selected asphalt can be mixed, and the results are somewhat encouraging in some cases. But I have not seen enough evidence of great improvement to warrant recommending that additional expense in pipe coating.

MR. S. B. BROWN.* Supposing we have selected a proper tar. Is there anything to be gained by its being applied to the metal so that it will be hard when the metal is cold? In other words, have we lost anything by the hardening of the coating, or is the coating which is semi-plastic, a little sticky perhaps, better than one which is hard? Of course I understand that you can take the same tar, and by a different temperature treatment get either a plastic or sticky or an enamel-like finish. Is there any difference in the desirability as between the two? Is it more desirable to have it plastic or not from a coating standpoint?

MR. CHURCH. It is very undesirable to have pipe hot enough to dry the coating too rapidly and leave an extremely brittle coating. I think that overheating the pipe is probably more dangerous, so far as the life of the coating is concerned, than underheating it. I do not think there is anything to be gained by having the pipe higher than 300°. Of course if you dipped an absolutely cold pipe in hot tar it would not dry for a very long time; you would have a pipe which you could not handle, as it would be too messy. I think the happy medium is to have the pipe just hot enough so that it will dry the coating slightly tackey. It will eventually set up firm and hard, but it will be slightly tackey for a little while. It can't remain too tackey or there is danger of its being more or less washed. In other words, it has to set up firm enough so that the water will run over it without disturbing the surface coating.

MR. BROWN. My thought in this connection was this: of course the undesirability of a sticky coating is purely connected with the outside of the pipe. The outside of the pipe is not really the point that water works people are interested in. The outside of the pipe won't give any trouble; it is the tuberculation from the inside. If you get a more desirable coating by leaving it a little sticky on the inside, we need not worry about the out-

* Of Warren Foundry & Pipe Co.

side. I notice that they put the wood pipe filler in when it is so sticky on the outside that they have to roll it with sawdust. Does that coating have any better life for that?

MR. CHURCH. I do not think we can directly compare the wood pipe coating with cast-iron pipe coatings. They use, or did use when I knew about it, a pitch of fairly high melting point, and while it is true that they rolled the pipe in sawdust, that pitch would be very hard without rolling it in sawdust, and it was thought a considerable protection to the coating until the pipe got in place underground. The pitch used was of such high melting point that an abrasion received by the pipe on its way to the job would have damaged the coating considerably if not protected.

I think, however, your coating should not dry too hard. That is a very good point.

THE PROPER TERM FOR WHICH WATER WORKS BONDS SHOULD RUN.

BY CHARLES W. SHERMAN.*

The reasonable or proper term for which water works bonds may be issued has no relation to the laws of Massachusetts or of any other state; and, as I shall show, the laws of Massachusetts relating to the issuance of bonds for water works construction show very little, if any, consideration for the *reasonable* term of life of the property covered by the bonds.

TERM AND AMOUNT OF BONDS INTER-RELATED.

The reasonable period or term of a bond is intimately connected with the life of the property covered by the bond. It is also related to the depreciation or loss in value of the property. Indeed, the two matters of *term* and *amount* of bonds cannot be separated in a discussion of the proper or reasonable length of term of bonds.

PROPERTY COVERED BY BONDS MUST PROVIDE AMPLE SECURITY.

It is self evident that bonds on a water works property, like a mortgage on residence property, should be amply secured; that is, the bondholder should know that the value of the property is sufficient at all times to cover the loan and to repay it at maturity.

Perhaps a further analysis of the conditions of a real estate mortgage will assist in developing a clear comprehension of the matter. Massachusetts savings banks are required by law to limit a loan on such a mortgage to 60 per cent. of the appraised value of the property; and the term is commonly five years. Under any ordinary circumstances the depreciation during this term would not be so great as to leave any question as to the property being sufficient to meet the loan at maturity; and extraordinary depreciation resulting from fire is guarded against by insurance carried in favor of the mortgagee.

Now suppose the borrower should want to give a mortgage for 40 years — which might perhaps be taken as representing the life of the ordinary house. On this basis the house itself would have little or no value at the end of the term of the mortgage; and the lender, if he used ordinary foresight, would not loan more than the value of the land alone, unless some arrangement were made for periodic repayment of sufficient principal to fully cover loss of value by depreciation.

This latter method bears a certain similarity to serial bonds, which will be referred to later.

* Of Metcalf and Eddy, 14 Beacon Street, Boston, Mass.

Life of a Water Works Plant.

If a water works plant were like the "One Hoss Shay," which, at the end of its life, went to pieces —

> "All at once and nothing first —
> Just as bubbles do when they burst."

and could be depended upon to render service until that time, then bonds might be issued against it for the term of its life, but with provision for a sinking fund to repay the loan at maturity, since the property would then have only a junk value; or, what is similar in many ways, with serial maturity of bonds for repayment of principal.

But a water works is a complex plant, made up of many items having widely different expectancies of life; and in growing towns it is continually being added to, so that the distribution system, for instance, consists of many parts varying in age from less than one year to the age of the oldest parts of the plant. In this country we have instances of cast-iron pipe 75 years old and still in service; but the *average* age of the distribution system containing these pipes is likely to be less than 20 years, because so large a proportion of the system has been added in recent years.

It is possible to make a fair estimate of the average useful life of an average or typical water works system, and such a figure will be of significance as a basis of comparison, although it should be used with caution in application to any particular case.

In a paper * by Metcalf, Kuichling and Hawley, presented to the American Water Works Association in 1911, they gave the percentages of the total values of a large number of water works plants, represented by the principal parts of such works. Averaging the figures presented I find that the value of the "typical" water works, based upon these particular statistics, is divided as follows:

Land and water rights	6 per cent.
Water supply works	9 per cent.
Pumping works	17 per cent.
Distributing reservoirs	6 per cent.
Purification works	11 per cent.
Distribution pipe system	51 per cent.
	100 per cent.

The useful life of these several parts from the point of view here under discussion may be taken approximately as —

150 years for land and water rights.
75 years for water supply works.
30 years for pumping works.
40 years for distributing reservoirs (including standpipes).
25 years for purification works.
50 years for distribution system (including services and meters).

* Some Fundamental Considerations in the Determination of a Reasonable Return for Public Fire Hydrant Service, by Lenoard Metcalf, Emil Kuichling and William C. Hawley. — Proc. Am. W. W. Asso. 1911, p. 55.

Then the average life of the entire system will be 51½ years — or in round numbers, 50 years.

Note: The U. S. Census Bureau " Uniform Accounts for Systems of Water Supply " (1911) states:

" Until further study and experience or a series of inspections and appraisals at fixed intervals furnish more accurate data, the average life of the various parts of the fixed properties of a water-supply enterprise may be assumed to be approximately as follows: For horses, carriages, automobiles, and laboratory apparatus and appliances, ten years; water meters, service pipes, office furniture and general operating equipment, fifteen years; boilers, steam pipes, and filtration equipment, twenty years; engines, pumping machinery, and wood pipes, twenty-five years; masonry of filtration plant, cribs, iron water pipes, intakes and connections, fire hydrants, standpipes, and buildings, fifty years; reservoirs, tunnels, and aqueducts, one hundred years; and for the water-supply system as a whole, fifty years. All these approximations are subject to modification by reason of any unusual conditions which may shorten or prolong the life estimated above."

The Committee on Depreciation, of the American Water Works Association, in its final report,* suggests;

	Years
For storage reservoirs, dams, and large aqueducts	75 to 150
For cast-iron pipe of large diameter	75 to 125
For cast-iron distribution pipe	30 to 90
For wrought-iron distribution pipe	25 to 40
For services	15 to 80
For distributing reservoirs	50 to 75
For standpipes	30 to 60
For meters	20 to 30
For pumping machinery	15 to 60
For boilers	15 to 30
For filter plants	15 to 50
For buildings	20 to 60

The Committee of the American Society of Civil Engineers on Valuation of Public Utilities † gives on page 1559 some data upon life of water works structures which had been abandoned. As would be expected, these related to works which had been outgrown or otherwise superseded, and therefore had much shorter lives than would normally be the case. The figures are therefore of no significance in this connection.

The average figure of 50 years' life for a " typical " water works plant is of no direct use, since it presupposes that all items of the plant are new at the same time, and that no renewals are necessary. Starting with an entirely new plant, of the " typical " character assumed, it does represent the average expectancy of life; if no extensions are required after 5 years the remaining life will be 45 years, but if extensions have been required the

* *Journal Amer. W. W. Asso.*, 1919, p. 85.
† *Trans. Amer. Soc. C. E.* 1917, p. 1311

average remaining life may be 46 years or more. The *remaining life* of the plant does not decrease uniformly from 50 years to 0, since the effect of extensions and replacements which add new elements to the plant at frequent intervals is to reduce progressively the rate at which the remaining life decreases. Indeed, after a time the remaining expectancy of life no longer decreases but remains substantially constant.

That such would be the case becomes obvious from a consideration of the conditions; and that it does as a matter of fact, has been amply proved by the figures of the large number of valuations of water works which have now been made of plants of all sizes and a wide range of ages.

Average Remaining Life is Proper Term for Bonds.

The average expectancy of life remaining after it no longer decreases is then a suitable term for which bonds may be issued in the case of the assumed typical plant. This remaining life of the plant will be the same now, next year, and five years from now.

The above statement is not precise in its application to any particular works, but is nearly so with any growing plant, or even in one whose growth has ceased, provided that replacements and renewals are made as they become necessary. That is to say, the effect of the long life ahead of new plant added for renewals and extensions will, *on the average*, offset the lesser remaining life of the old plant due to increasing age. In practice the expectancy of future life generally decreases gradually during a term of years, while only minor extensions and renewals are made, and then increases abruptly when important additions to plant are made; the average result corresponding to a relatively uniform expectancy of life.

Determination of Remaining Life.

The average remaining life expected is rarely estimated or stated in reports of valuations. The amount of the accrued depreciation upon existing plant is, however, practically always stated, and its ratio to the reproduction cost (or original cost) of existing plant is easily obtained. The relation between accrued depreciation and elapsed proportion of the total life is a direct one; and if the average total life can be taken as a constant — say 50 years — the remaining life follows directly.

For this estimation the *total* accrued depreciation, including that on abandoned structures, should be used, and compared with the total cost, including that of the same abandoned structures. The figures should be based upon complete records for works of a considerable age, not less than 20 years; figures for works of which the record of abandoned structures is lacking or incomplete are less satisfactory, and require some adjustment before being used.

A sufficient number of complete records, covering both large and small works, automatically includes the *normal* percentage of complete deprecia-

tion, due to accident, obsolescence, or other causes resulting in less that the usual life for some structures, and the figures obtained from these records furnish a basis for approximate adjustment of data covering only the depreciation of existing plant.

In a paper entitled "Practical Checks upon Water Works Depreciation Estimates"* Mr. Leonard Metcalf has submitted a table of "Depreciation Records of Some Old Water Works" which contains eleven such complete records; and other data not included in the published paper bring the number to thirteen. The total accrued depreciation in these thirteen cases averages 19.7 per cent., the range being from 7.2 to 27 per cent. Omitting the lowest record as abnormal, in view of its divergence from the others, as well as the known circumstances making for a low depreciation, the range is from 13.3 to 27.0 per cent. and the average 20.7 per cent.

Assuming that depreciation accrues on the basis of a geometrical progression, corresponding to the growth of a sinking fund earning 4 per cent. interest, a total accrued depreciation of 20.7 per cent. on a plant of 50 years' total life, corresponds to an age of 20 years, and a remaining life of 30 years.† The range of depreciation from 13.3 to 27.0 per cent. corresponds to remaining life of 36 to 26 years.

On the basis of these figures the conclusion is obvious that under normal circumstances the fair term for water works bonds is 30 years, and that in individual cases it should seldom be less than 25 or more than 35 years.

Residual Value.

These same figures of accrued depreciation indicate that there is still remaining in normal works a value of approximately 80 per cent. of their cost, the range being from 73 per cent. to 87 per cent. (The figures given have been based upon reproduction rather than original or actual cost, but the proportions would differ but slightly if at all if figures of actual cost had been used.)

In references to cost or value in this paper the physical plant, only, is meant. Items of value not represented by the plant are omitted from consideration as having no bearing upon life of the property, or upon the part of the value which may properly be covered by bonds.

An examination of the records of accrued depreciation for a large number of other water works, mainly those for which there is no record of abandoned property, indicates that the above figures are conservative. After adding reasonable allowance for the effect of abandoned property, there seems to be a decided majority of plants in which the accrued depreciation is less than 20 per cent., and but few in which this figure is materially exceeded.

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* *Journal Amer. W. W. Asso.*, 1919, p. 371

† If the average total life were 60 years, the remaining life corresponding to 20 per cent. depreciation would be 33 years; and for a 70-year total life, the remaining life would be 35 years.

Reasonable Term for and Amount of Water Works Bonds.

It therefore appears that the fair or reasonable term for water works bonds is 30 years, and that 80 per cent. of the cost may be covered by bonds, which will be suitably secured by the property covered.* Under exceptional circumstances the term may be reduced to 25 years and the percentage of cost to be covered by bonds to 75.

Municipal Water Works Bonds.

In the case of bonds of municipal works, the property is not the sole security for the bonds, as the credit of the municipality is pledged. The bondholder is, therefore, suitably safeguarded even if the entire cost of works be raised by bonds. Indeed, such procedure is usually the only one possible in the case of new works, and is justified by the fact that the anticipated life of the works at that time is 50 years or more; but in the case of enlargements or extensions it is certainly the case that conservative financing would require that such works be self-supporting and that neither the amount nor term of bonds be greater than would be proper in case of private corporation ownership.

Massachusetts Laws Affecting Municipal Water Works Bonds.

In Massachusetts, the laws regulating the issuance of bonds for municipal water works have been framed from the point of view of limiting and regulating municipal indebtedness, without sufficient consideration of water works as a utility which should be self-supporting, and the financing of which should therefore be subject to the same conditions as would be proper under private ownership. This condition resulted from the fact that a number of cities and towns had issued bonds far beyond reason, and in some of them water revenues had been diverted to other municipal departments while construction of any kind, including replacements and renewals, was financed by bonds. In an attempt to cure this condition laws were enacted which have caused considerable hardship to those responsible for water works financing in this state.

I had occasion to comment upon these laws before this Association in 1916, when Wm. S. Johnson, Henry A. Symonds and myself submitted a paper † discussing these provisions and their effect in detail, and offering suggestions for amendments which we were then attempting to have enacted. We succeeded in getting only a small portion of the relief for which we asked, and the present law is substantially the same as it was at that time. It is codified in Chapter 44 of the General Laws, Sections 8, 9, 17, 19, 20 and 22. The most significant portions are as follows:

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* This statement must not be taken to mean that it would be good corporate financing to issue bonds to the extent of 80 per cent. of the physical property; nor that items of intangible property should be omitted from capitalization.

† Municipal Water Works Financing in Massachusetts, as Affected by Recent Legislation, JOURNAL N.E.W.W.A., Vol. 30, p. 779.

"Section 8. Cities and towns may incur debt, outside the limit of indebtedness prescribed in section ten, for the following purposes and payable within the periods hereinafter specified":

. . . . . .

"(3) For establishing or purchasing a system for supplying the inhabitants of a city or town with water, for the purchase of land for the protection of a water system, or for acquiring water rights, thirty years.

"(4) For the extension of water mains and for water departmental equipment, five years."

. . . . . .

"Debts mentioned in clause (1) of this section shall be payable as provided for in sections four, five, six and seventeen. Debts for all other purposes mentioned in this section shall be payable within the periods above specified from the date of the first issue of bonds or notes on account thereof, and may be incurred in accordance with the laws relating to such purposes, so far as they are consistent with this chapter. Debts, except for temporary loans, may be authorized under this section only by a two thirds vote."

. . . . . .

"Debts mentioned in clauses (3) and (4) of this section shall not be authorized to an amount exceeding ten per cent. of the last preceding assessed valuation of the city or town."

(General Laws of Massachusetts, Chap. 44, pp. 361-362)

Under this law it is impossible to borrow money for water works extensions for a longer term than 5 years, so that whenever conditions arise making it impracticable to finance necessary construction by 5-year serial bonds, special legislation must be obtained.

I grant the desirability of some central authority maintaining close control over municipal financing, and that some method must be provided to prevent a misuse of power in this matter, such as formerly existed in some cases. Perhaps this could be accomplished in part by a general law providing that all revenue from water works operations should be devoted to water works purposes and not diverted to other uses — it being understood, of course, that payment of interest and principal upon debts contracted for water works construction, is a proper use of water works revenue.

Special Legislation Undesirable.

With regard to the propriety of bond issues and the amount and period of the bond issue, it seems to me that this is a subject which ought not to be referred to the Legislature. Its proper decision demands a detailed knowledge of conditions affecting public utility operation, financing and management, which the Legislature and its committees cannot have. Moreover, it is extremely undesirable that the time of the Legislature be wasted in considering appeals for special legislation, attempting to analyze the propriety and desirability of the laws desired, and cumbering the statutes with special legislation applicable only to particular cases.

The sensible manner of handling subjects of this kind would seem to be a general law referring all such cases to the Department of Public Utilities, which now has jurisdiction over the issuance of bonds and stock by private corporations operating public utilities, and which is best fitted of any State authority to deal with this subject.

In view of the fact that the credit of a municipality is pledged, and not merely the particular works for which bonds are to be issued, it is probable that some general requirements limiting the power of the Department of Public Utilities to approve bond issues in accordance with the financial standing of the particular municipality, would be advantageous;* but the general principle of referring the whole matter of water works financing—municipal as well as private—to the Department of Public Utilities, seems to be sound and to the advantage of the community as a whole.

Present Situation of Belmont.

An instance of the hardship imposed in attempting to comply with the present law, and the resulting necessity of applying to the Legislature for special legislation, is afforded by the present conditions in the town of Belmont. The water works of this town have been self-supporting for many years, and under conditions existing before the war ordinary extensions were easily taken care of out of surplus revenue, in addition to paying interest and bond requirements upon the water debt.† During the war construction work was kept at a minimum and a material balance was accumulated. As such a balance is always looked upon with envious eyes by town officers anxious to keep the tax rate at a minimum, authority of the town was asked and obtained, to transfer $5 000 to the water sinking fund, thus building up the fund to such a point that it, with its accumulations will take care of all the sinking fund bonds outstanding, without further contribution. Five thousand dollars were also appropriated to the general funds of the town, since at that time there was no indication of the abnormal demands of water works extensions which were soon to develop.

The growth of Belmont since the termination of the war has been at a phenomenal rate. This is indicated distinctly by the number of services installed in recent years, as follows:

Year.	New Services.
1918	19
1919	59
1920	100
1921	136
1922	210 (approximately)

The population, which was 10 749 according to the census of 1920, now approximates 14 000.

* Perhaps the provisions of the General Laws quoted above, by which the total water works debt is limited to 10 per cent. of the assessed valuation, is sufficient, although the percentage is too high.

† But the total amount of bonds outstanding was only about $55 000, against works which had cost upwards of $200 000.

This growth has been accompanied by a corresponding real estate development which has demanded material extensions of the water works distribution system. The amount expended for construction during each of the last four years has been approximately as follows:

1919	$5 785	1921	$30 739
1920	23 318	1922	31 000

Prior to the war, and under normal circumstances since the war, there would be available from water revenue, approximately $13 000 each year for extensions, after meeting operating and fixed charges. Since 1919, however, the actual cost of the extensions required has ranged from $23 000 to $31 000, and there is no indication that this expense will be materially reduced in the near future.

In 1920 nearly $11 000, in addition to the surplus for the year, was required for construction. This was taken from the balance brought forward from the previous year, thus reducing the balance with which the department began the year 1921, to approximately $9 000, and as no further collections were made until after June 1, this sum was obviously inadequate to the needs of the department.

In 1921 approximately $13 000 surplus revenue was devoted to construction, and in addition $15 000 were borrowed on 5-year serial bonds, in accordance with the general law. The total cost of construction was, however, nearly $31 000, with the result that the department's balance was still further depleted to approximately $6 500.

During 1922 it became necessary to repay $3 000 on the serial loan of 1921, in addition to the increased interest requirements, so that in spite of larger earnings the surplus available for construction was reduced to about $11 000. Twenty thousand dollars additional was borrowed, again on 5-year serial bonds, providing a total of about $31 000 for construction, which is approximately the amount actually expended. The balance at the end of 1922 is therefore substantially the same as that with which the year was started.

With $3 000 of the loan of 1921 and $4 000 of the loan of 1922 maturing in 1923, the surplus available for construction will be reduced to approximately $6 500. The construction requirements are not likely to be less than those of 1922 and may be considerably increased. The Commissioners estimate $35 000 as the probable construction cost. In view of the depleted condition of the balance it seems desirable to borrow $30 000 of the estimated requirement of $35 000, thus allowing a small addition from surplus revenue, to the working balance.

This money, like that borrowed in 1921 and 1922, might be obtained on 5-year serial bonds, and the needs of 1923 would thus be met without particular difficulty. It would, however, add a further sum of $6 000 per year to the amount annually required for repayment of bonds, beginning in 1924, and there would therefore be only about $1 500 of surplus earnings available for the construction of that year, and it would become still more necessary to borrow substantially the full amount required for construction.

The point has obviously been reached where it is a distinct hardship to borrow further on 5-year bonds, and where it is necessary to apply to the Legislature for special legislation, allowing the issuance of bonds for a longer term. In view of the comparatively insignificant amount of bonds outstanding against these works, ($78 500 as compared with a total cost of about $300 000), it is hoped that this legislation can be obtained.

Conclusion.

Summarizing the statements in this paper, its conclusions are:

1. The average life for a " typical " water works plant in this country is about 50 years. It will rarely be less than this in individual cases, and may be as much as 60 years or more for some works.

2. Complete records of depreciation, including abandoned structures, of a number of water works plants of considerable age show that the total accrued depreciation of the physical plant of such works is about 20 per cent. of the cost. Departures from this mean are not great. Records of depreciation suffered by the plant still in service, modified by a suitable allowance for plant abandoned, confirm this as a reasonable normal figure.

3. The corresponding average age for works of 50 years' life is 20 years, leaving 30 years average remaining life. If the average useful life were 60 years instead of 50, the average age would be 27 years and the remaining life 33 years. Thirty years is a fair estimate of the average remaining life of any water works plant in normal condition, and therefore a proper term for which water works bonds should run.

4. If the works have suffered a depreciation of 20 per cent. including abandoned property, there is a residual value of 80 per cent. of cost of the physical plant. Water works bonds may therefore safely be issued up to 80 per cent. of the normal cost of the works.

5. Municipally owned water works should be self-supporting, and their financing should be on the same general basis as that of private corporations.

6. The clause of the present Massachusetts law which limits bonds for the extension of municipally owned water works to a term of 5 years is illogical and burdensome, and should be repealed.

7. Special legislation for particular cases, made necessary by the existence of the 5-year limit, is undesirable from every point of view.

8. Suitable control over municipal bonds for water works purposes can be exercised by requiring the approval of the Public Utilities Commissioners in exactly the same way as for bonds of a private water company.

9. Misuse of water revenues can be avoided by legislation limiting their uses to water works purposes.

Note: Since the presentation of this paper my attention has been called to an editorial article entitled " Municipal Loan Purposes and Periods in England and the United States" in *Engineering News* of November 2, 1905, p. 463. Besides a statement of the conditions under which loans could be made in England, it includes a very interesting and suggestive discussion of the principles which should govern in such cases, and might well have provided the text for such a paper as this: but most of the data upon which my conclusions have been based were not available at that time.

DISCUSSION.

THE PRESIDENT. As stated in the notice of the meeting, we had hoped to have with us today the members of the Special Commission on Municipal Taxation. They have, however, both this morning and this afternoon, hearings in connection with the cities of Fall River and New Bedford, and are unable to be present. They have just now telephoned me, saying that they would very much like to meet the representatives of this Association at some special meeting to be called for the purpose, and that they are distinctly interested in our viewpoint on this problem. I presume we shall be very glad to appear before them.

While we have not been able to bring here the Commission, we have with us the principal hurdle over which we must climb in this financial problem, Mr. Waddell — Director of Accounts of the Department of Corporations and Taxation. I know we all want to hear from Mr. Waddell.

MR. THEODORE N. WADDELL. Mr. President and Gentlemen: I am in a very fortunate position — fortunate, I think, for me, in that I have more or less of a rhinoceros hide. I am always on the wrong side of the question. However, I would like to say that I believe my heart is in the right spot.

Now there are certain conditions which I meet with that are not fully appreciated by those who work from a scientific standpoint. I am not in a position, nor am I disposed to believe that the points which have been mentioned are open to criticism. We have, however, a situation surrounding us, political and otherwise, that must be met.

I want to explain briefly the 5-year clause of the law relating to the extension of water mains and for water departmental equipment, and give some experiences I have met with concerning its operation. When a report of the examination relative to municipal finances was made by our department in 1912, I thought it would be a good idea to have our suggestions passed upon by an organization that was then holding its meeting, and I therefore suggested that we submit certain of these recommendations to the treasurers of the various cities and towns at their meeting. We had a very pleasant reply from them, (?) giving unanimous disapproval of the recommendations. Later, another conference was arranged and then a unanimous vote of approval was given.

Now, on the 5-year proposition. The committee, at the time the matter was considered, hesitated to make provision for extensions into new territory, believing that cities and towns should come to the Legislature each and every time an extension was desired. Now, I am always satisfied with a bite out of an apple if I can't get the whole apple, and I am convinced that in fully 50 per cent. of the cases where they have used the 5-year provision, it has been ample. I am thoroughly convinced, however, that the present general law is inadequate to meet all of the needs of our municipalities. You are familiar, I presume, with the fact that there

is a statute which requires me to report to the Committee on Municipal Finance on every bill calling for the borrowing of money. It is rather embarrassing to make a report against one's own judgment, but these reports are necessarily statements of facts as I learn them and it is left for the committee, after hearing all the evidence relating to the subject in question, to act as it deems proper. But it seems absolutely unfair to me for one city or town to be authorized to borrow for 30 years; another for 15 years; another for 20 years; and perhaps another for 25 years. It is absolutely unfair and unreasonable. I personally believe that annually recurring costs, whether they be for water main extensions, building schoolhouses, or building streets should be paid direct from revenue. We are told to let posterity pay the costs, but posterity has several troubles being passed down to it. The policy of paying as you go, for at least the annually recurring costs, is, in my opinion, sound.

Now, as to the cost of interest — I was on the unfortunate side on that in 1916. I stated to the committee, or to the Special Committee of the Association which appeared before the committee, that I believed they were getting what they did not want and were not getting what they really wanted. Now, that law has been on the statute books some 6 years and has been availed of probably three times in the 6 years. In that 6 years, I think it is a safe assertion to make that there have been at least 50 to 75 special bills passed.

The reason I speak of that 5-year exemption is a matter of psychology. When you are getting something now, something that is of great benefit, you pay for it willingly; but we find that we have outgrown many of our systems — the street mains need to be relaid and it is not practical to relay them from water revenue, neither is it possible, under the general law, to relay them by a loan. I firmly believe that there should be some provision for meeting this difficulty, and I had the audacity to recommend, when the consolidation of the laws was being made, that an amendment to what is now Chapter 44 of the General Laws be considered by providing that cities and towns might borrow for from 15 to 20 years for laying or relaying street mains of 6 or 8 inches in diameter. Now, I haven't any idea whether that is scientifically correct or not, but I have an idea that such an amendment would relieve the Legislature of a great many special bills. I also recommended that provision be made for the construction of reservoirs and standpipes, with a like term for loans. Under the General Law, as I understand it, you cannot borrow for that purpose at all — not even under the 5-year provision.

Now, to show how things work out — and no doubt there are gentlemen here who have been in the Legislature, and know the legislative machinery, so that it does not seem quite right or proper for me to criticise them — but in the present year, 1922, I had this experience. A certain person came in who had been both in the House and the Senate — a very pleasant gentleman to meet and a very able man — and he said: "We

are up against it in our water works; we must have a special bill through." I therefore drafted a bill for him in the usual broad form, and this was reported and enacted in a very short time. It was impossible for me to tell the standing of the past loans of the town in question, but in following them through I discovered, after the Legislature had adjourned, that there was a special act on the statute books allowing borrowing for the purpose in question that had been there for, I guess, some 10 years, and it had not even been touched — not a single dollar had been charged against it.

In 1913, within a few weeks from the passage of the General Municipal Indebtedness Act, one of our cities secured a special act which permitted it to lay a large main from a reservoir down into the city. It was recognized by the committee in 1912 that water legislation could be sought constantly by the cities and towns. I know, in fact, of only one city that I can recall that was absolutely refused legislation. This was refused, I think, for the reason that one of the petitioners made the statement: "You see we have the lowest water rates in the State," giving their minimum charge at $6.00, and I am not sure that this rate was not the maximum. I think the charge was a flat $6.00 Well, they did have a low rate, and naturally the water works went to pieces, and so far as I know it is about in that condition today. It is impossible for them to give an adequate supply of water. I can recall only that one city that was absolutely refused legislation.

Now, there is no question but what special legislation will be granted under proper conditions. I agree with you that it ought not to be necessary to seek such legistation. Unfortunately, I am in a position where the majority of the members — in fact, the committee — are in disagreement with me. I was in hopes, and I expressed to the President of your Association, that he would go before the commission now sitting to urge, and that the commission would recommend, legislation that would relieve the Legislature of a number of these special acts. I know they regret very much that they could not be present at this meeting and get first hand from you your feelings in this matter, but it was stated just before adjournment of the commission today that they hoped that a committee of your Association would appear at a meeting and discuss this question from your standpoint. Personally I would like to see the legislation broadened so as to permit borrowing for a reasonable period of time for street mains, for reservoirs, and for standpipes. I do not say that that would cure all of the evils, but it would be very helpful and would reduce the present special legislation to a minimum.

So far as ordinary extensions and their connections are concerned, it seems to me that it is perfectly right and proper that these annually recurring charges should be put into the tax rate. Now, when you consider that the interest cost on a 5-year loan is practically 12 per cent. or upwards, on a 10-year loan is 22 per cent., on a 20-year loan is 42 per cent. plus, and on

a 30-year loan is 62 per cent. — or under the plan with the 3-year exemption is 70 per cent. — of the original cost, the interest is quite an item. And I think, furthermore, when you realize that the bonds of Massachusetts municipalities are selling on the market at a lower rate than those of any other State in this Union some credit is being given in return for the splendid Municipal Indebtedness Act of 1913. It is not perfect by a long ways. It is not easy to amend; but I sincerely hope that certain amendments can be obtained that will relieve special legislation.

I do not question for a moment the intent of the members of the Legislature, because they are trying to carry out in principle some of the laws which were enacted as the result of special study and I hope they will continue to do so. However, we must recognise that there are certain weaknesses in the law, and I would like to see them bolstered up. It is not at all pleasing to me to have all the dirty linen of all the cities and towns in the Commonwealth washed out at a public hearing, and we always have more or less of it at such hearings.

In comparing municipal plants with private plants, there is one thing I think you ought to bear in mind. No private plant will extend mains where no appreciable return will be received for many, many years. Municipal plants are very likely to extend mains where nothing like adequate returns will be received, and for that reason I question whether or not it is fair to assume that a municipality ought to be allowed to incur debt for construction, for capital purposes, to the degree that you naturally will expect in private plants. I think it has a bearing, knowing the town governments as I meet with them. In my own town, to my knowledge, we have not borrowed for water works for 12 years. I think they have a very comfortable working balance. We have a very reasonable rate, but I feel sure that 100 of the fire hydrants could be eliminated in our town if the existing street mains were replaced by larger mains. How long present conditions will continue, I am not sure, but I do know this — there is not a great deal of advantage in having an extra pump come in to fight a fire when one pump has just about milked the pipe dry. We do outgrow water mains, and very few, if any, municipalities are willing to take the criticism which would follow the installation of new mains that would be adequate for 50 or 75 years. I think it would be almost impossible to get them to do it. So that you have to recognize that you have not only depreciation on account of the life of the mains, but you have a further depreciation on account of necessary renewals.

I did not intend to say very much except to call your attention to the Act of 1913. The 5-year clause particularly was not put in with any idea that it corresponded to the life of the mains, but it was the only relief that it seemed possible to get at that time. It is a good deal like the 25 cent clause on departmental equipment. I have been laughed out of court several times on the matter, and the only way you could convince the committee at that time was to say to them: " Here is a town of a half

million valuation; they want a road roller, and towns do need road rollers. Is that town going to put $7.00 or $8.00 on the tax rate to buy a road roller?" Now, a dollar is a dollar, and it is just as much a dollar in the small town as it is in the city. You take the 25 cent clause in Boston with its one and three-quarter billion — they have to get three or four hundred thousand dollars in equipment before they can borrow a nickel, but when you get into the small towns, they have only a very small amount in the tax rate, so that relatively it was all right. I think it has worked out very comfortably for all our municipalities.

But whatever the right period is for a loan for relaying mains, standpipes and reservoirs, it seems to me that you ought to arrive at some solution of that problem and thus eliminate, I should say, at least 90 to 95 per cent. of the special acts.

MR. SHERMAN. I have been greatly pleased by what Mr. Waddell has said, and to learn that he and I are so very closely in accord. In the last analysis, what he has said and what I have said come pretty nearly to the same thing.

One of my inferences, is that the 5-year limitation on bonds for water works extensions, resulted from a "trade" in the committee. I have no question that some kind of legislation was necessary, but when you compare the particular clause of the law which limits our bonds to 5 years, with the following one which allows 20 years for gas and electric lighting bonds, you see that there is absolutely no consistency between them. Either water works men did not know what was being done, or were not properly represented at the time this legislation was put through.

I think that the term and proper amount of any municipal water works bond issue ought to be fixed with reference to circumstances of the particular case, by some authority which may be considered more or less expert in that line, and which is constantly dealing with such matters. It seems to me the Public Utilities Department is the natural one to have such jurisdiction. Municipal water bonds, although issued to provide funds for some specific improvement, are not secured by any particular part of the works, but by the plant as a whole, and with the credit of the municipality behind them. There is no particular reason, therefore, to limiting the term of some bonds to say 10 years, and allowing perhaps 30 years for others, especially if no bonds for 50 to 75 years are issued when bond purchases are made, or very long lived structures are built. In general, for water works as a whole, 30 years is a fair term for bonds which will be properly secured during their life, if not issued for more than 80 per cent. of the cost of the works.

One other point which Mr. Waddell has stressed — and it is a very important one — relates to the constant diversion by some of our cities and towns of water works revenue to other municipal uses. It is an evil which we as water works men must undertake to cure. It can't go on indefinitely if the water works are to be on a proper basis. Just what

kind of legislation would assist in doing that I am not sure, but I think some kind of a general law could be framed, and I hope it could be passed, which would absolutely prohibit the diversion of such funds.

The water works utility, if owned by a municipality, should be run entirely separate from other municipal affairs. Its earnings should be devoted to the Water Works Department.* The Water Commissioners should be required to establish rates sufficient under ordinary circumstances to cover the interest on debt and the debt retirement requirements, operating expenses, and such ordinary extensions as are, as Mr. Waddell puts them, annually recurring expenses — things that can be foreseen and expected. On the other hand, once in a while the need arises in any growing city or town, for a radical reinforcement of the plant, and borrowing is the only way to properly meet such a contingency. If the sum required is a large one, you do not get great help from your borrowing if you have to repay in 5 years; you do not get as much as you ought if you have to repay in 10 years. Whether it should be 20, 25 or 30 years is perhaps something for argument.

The Legislature can very well establish general principles and limits which must be conformed to, but the Public Utilities Department, or some other competent body, should do the regulating.

Mr. George F. Merrill.† I was very much interested in Mr. Sherman's paper, and I was glad to hear Mr. Waddell bring out the things which he did.

Every water works man throughout the State knows that almost any system that was designed as early as 1872 is wholly inadequate to furnish service to anywhere near the insurance requirements today, and I believe that bond issues should be provided for renewals.

I also think that we need a clearer interpretation of what constitutes a renewal. For instance, in one case I know of it was desirable to lay a 16-in. pipe in a street that only had a 4-in. We were informed that an interpretation was received from the Bureau of Statistics that that would be a renewal and we could not issue bonds on it. However, if we had laid this 16-in. pipe on the other side of the street and left the 4-in. pipe in service where it was, it would have been new construction. That is a point that should be cleared up. I think it would not be desirable to specify in the law the size of pipe which would constitute renewal. In some cases it may be a size of 3 or 4 in. increased to 12 or 16. It is a matter of local conditions.

I also think Mr. Sherman made a very good point in the comparison of the 20-years time of bond issues for municipal electric light and gas plants, with water works issues, and it might be to the point to state that

* In some cases it may be practicable to assess sewer users in this form of additional water rates, and thus provide the money necessary for maintaining and operating a sewerage system without recourse to the general tax levy. Such a practice is not really in contravention of the above principle, but a special form of assessment for sewer maintenance, and the accounts ought to be kept in proper form to show it as such.

† Superintendent Water Works, Greenfield, Mass.

their depreciation is about 10 per cent. while the water works depreciation is far less. It is a rather illogical part of the law.

I think we are getting a good deal of good out of this discussion.

PRESIDENT BARBOUR. It is a fortunate thing for Mr. Waddell that there are no insurance men here, apparently. This is the first instance I have ever heard of where there were too many hydrants.

Reference has been made to the different methods of handling bond issues for privately owned plants, which come under the supervision of the Public Utilities Commission. We have with us a member of that Commission, and we would like, I know, to hear from Mr. Wells.

MR. HENRY G. WELLS. Mr. President, and Members of the Association: There is not very much that I can say to you gentlemen except what appears upon the statute books of the Commonwealth, with which you are all doubtless familiar.

I am reminded a little bit of the famous colloquy between Chauncey Depew and Rufus Choate at a dinner. They were both seated at the head table, and Depew said to Choate: "Well, this is another case of a nickel-in-the-slot machine. You put down a lunch and a speech comes up." Choate replied: "Yes, and sometimes you put down a speech and a lunch comes up." Depew thereupon replied: "Well, it is better to have lunched and lost than never to have lunched at all."

After hearing all the tales of woe from members of the Association, and also from Mr. Waddell, I trust that all of your companies are not in the same situation that some of the other Public Utility companies are in. They tell the story about a railroad out in the middle west, which two men were discussing, and one man said, "Don't you know that railroad is of Divine origin?" "Divine origin?" said the other; "how do you make that out?" "Why," the first man said, "you know in the first book of the Bible it tells about how God created all creeping things."

I trust our companies haven't got in that state yet, although there is some talk about pressure over here on the part of Mr. Waddell.

Some little suggestion was made here that perhaps the municipal plants might like to come under the control of our Department. Now, I assure you, gentlemen, that we are not looking for any more work; we have troubles enough of our own now. About a year ago the Legislature wished on us — by what legislative reasoning I do not know — the enforcement of the so-called "Blue Sky" law. What the sale of securities has to do with public utilities I do not know — the sale of private securities, at any rate; but, nevertheless. we are trying to administer that law, and along with our other duties it gives us trouble enough.

However, to come specifically to the suggestion made by your presiding officer, private water supply companies come under our jurisdiction to the same extent, practically speaking, that gas and electric light companies do.

Reference has been made to the provision relative to municipal gas and electric plants where bonds are issued for 20 years. As to private gas and electric plants and private water companies there is no provision as to the length or period of time. We were told until a short time ago that bonds could be issued up to the same amount as the capital stock: That is, they should be relatively 50-50; that they should bear interest at the rate of not exceeding 6 per cent., and could be secured by mortgage, but should be issued under such terms and conditions and restrictions as the Department might lay down. In view of the financial stress of the past few years that law was changed, eliminating the provision that the bonds should not exceed 6 per cent., and providing also — I neglected to state that these bonds must be issued at par — providing also that bonds which were issued under a pre-existing mortgage could be issued below par if the Department so approved. In other words, where there was an existing mortgage and corporation bonds had been issued at 6 per cent., future bond issues must also be issued at 6 per cent., and under those circumstances the bonds could be issued at less than par. That, I believe, is the general provision affecting gas and electric companies privately owned, and also relates to water companies privately owned. So that any private water supply company petitioning the Department for an issue of bonds comes to us and we turn the figures submitted over to our Accounting and Engineering Departments, and they are gone into thoroughly and under the law we prescribe that those bonds, whatever we allow, shall be issued at a certain rate of interest, and that the proceeds on those bonds shall be devoted to certain specific purposes, usually set forth in the petition.

I think one of the speakers referred to the fact that bonds ought to be allowed to be issued up to 80 per cent. of the value of the plant. I assume, of course, that he is referring in that instance to the municipally owned plants, because as to privately owned plants with an issue of stock outstanding, I do not believe he would agree that they ought to be allowed to issue bonds up to 80 per cent. of the value of the plant. Certainly those gas and electric companies which during the war had an outstanding bond issue of an amount, say, equal to 50 per cent. of the stock, found their credit in a very precarious situation. In other words, the gas and electric companies which had small outstanding debts, as represented either by notes or bonds, during the financial stress found themselves in much better condition and could render much better service to the community than those companies which had large outstanding debts represented by notes and bonds.

Now, of course if the Legislature in its wisdom, and with its power of determining principles, should give to the Department of Public Utilities the jurisdiction over municipally owned water companies, we would assume the burden with as good grace as we could.

But I want to suggest one thing: Having been a member of the Legislature for a considerable period of time, I know you will encounter this proposition: There is always running through that membership an

intense interest in the so-called principle of home rule, and I am afraid you will find that if an attempt is made to put municipally owned water companies under the Department of Public Utilities, you will immediately stir up a cry of centralization and taking away the principle of home rule from those municipalities. I simply want to throw that out as a suggestion, because I have seen that done so many, many times.

I thank you, Mr. President.

MR. REEVES J. NEWSOM.* Mr. President, while Mr. Waddell is here to comment on the matter I would like to point out an illustration of the requirements of the water department and its relations to the 5-year term in the Municipal Finance Act.

The City of Lynn Water Department, until 1921, had for its use all of its receipts. As a result of that no money was ever borrowed for anything except permanent extensions to the supply of the system. That is, all the bond issues were 30-year bond issues. Beginning last year the system was changed and a specific appropriation was made for the water works and the receipts were turned into the general revenue. The result was that the size of that specific appropriation was such that nothing but ordinary operative maintenance could be carried on, and it became necessary to borrow money for all extensions to do work. It was impossible to put any services to new houses or install a meter or lay a new main without borrowing money for that purpose. And the result is, of course, that we have had to issue a lot of those 5-year bonds.

Now, Mr. Waddell pointed out the evil of issuing bonds for annually recurring expenditures, and this is an instance of how the city has been forced to do that very thing, because it is not allowed the use of the revenue which it gets from the water.

MR. FRANK E. WINSOR.† In applying the conclusions of Mr. Sherman's paper to specific cases, I would call attention to a danger in using general statistics of this kind, which may be overlooked and which should always be borne in mind in fixing the date of maturity of bond issues, namely, obsolescence. The considerable number of water works structures which become obsolete in a relatively short time is perhaps not appreciated by many of us. For example, I have in mind a filter plant of 10 acres which after an average life of less than 20 years will become obsolete, also pumping plants, buildings, etc. which will become obsolete after lives varying from 10 to 50 years. Similarly, parts of a distribution system frequently become obsolete from the necessity of replacing small pipe by larger pipe.

MR. WADDELL. I do not think I made clear the situation under the 5-year statute, and I would like also to make clear the position that I occupy.

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* Commissioner of Water Supply, Lynn, Mass.

† Chief Engineer Water Supply Board, Providence, R. I.

It is not my purpose at any time to attempt to influence legislation, except to maintain standards, and it seems to me that your Association must appreciate the proposition that you are facing, and while you may not get your ideal at the outset, if you work in that direction you will arrive at it much quicker than by trying to take everything knowing that you won't get anything.

The pay-as-you-go basis, I would like to say, should be followed, not only in connection with the water works. In my own town, we started off by eliminating borrowing for sidewalks that we could put in the tax rate every year; then we eliminated borrowing for annually recurring costs on the streets, and for annually recurring costs on sewers.

Do not understand me to say that if you have a large project, you should not borrow, because I believe you should; but I am cutting out the annually recurring costs. If you are building schoolhouses every 5 years, you should not have a 20-year loan to pay for them.

I have incessantly advocated an appropriation by the municipality for fire service as well as for department charges. We have always advocated that, and fortunately we get it in most municipalities now. I am not bothered so much as to the separation of the actual cash as you are, naturally, but I am very much interested in showing what is actually being earned and what is actually being expended.

In whatever legislation you seek, I would only say that, if I have any influence, I shall be glad to use it, for I always like to pass along any information I have, believing that by and by we shall, at least, accomplish a part of our ideal if not the whole of it.

MR. SHERMAN. In response to the point raised by Mr. Winsor, I want to say that the statistics of which I made use in arriving at the general conclusion include many large works in which there have been unquestionably and unavoidably a very considerable number of cases of just the kind of obsolescence he referred to. The fact that the statistics include detailed history of abandoned plants of the Portland, Maine Water District, the Denver Union Water Company, the Pennsylvania Water Company, the Spring Valley Water Company of San Francisco, and the Indianapolis Water Company, besides a number of smaller ones, of itself shows the impossibility of such obsolescence having been avoided in making up the depreciation estimates. The statistics for these cases are very complete and very trustworthy, and they are the sole ones on which I have depended in making up this general estimate.

MR. HATHAWAY.* Mention has been made regarding the appropriation by municipalities of budget moneys for this and that purpose and including water works funds and its purposes.

I am aware that most of the so-called " budget experts " and municipal research theorists do not agree with me in the opinion that a municipally-

* Water Registrar, Springfield, Mass.

owned water works should not properly be included in the city's annual budget.

The listing of any *self-supporting* " *public service enterprise* " in a budget of governmental departments entirely supported by tax levy only results in mystifying and misinforming the tax payers and the general public, in whose minds the " budget" means but one thing, viz.: the apportionment of their *taxes* to the various governmental requirements of the year.

I am sure that every thinking person will admit the truth of this statement upon serious consideration.

One of my good friends at home (a prominent lecturer and a man of more than ordinary intellectual attainments) some years ago said to me, "I see that in my copy of the city's proposed budget for this year appear appropriations for payment of water bonds, for water bond interest, and for water works sinking fund, and you told me a while ago that our water works is a self-supporting enterprise and that none of my taxes are used or needed for such payments! What does it mean?"

I replied that " Of course you, as well as other interested taxpayers, would not be apt to notice that on one of the first pages are listed certain items of estimated revenue from fees, licenses, and other sources, together with only enough of water works revenues to *offset* the so-called *appropriations* for water works purposes; so that such "appropriations " are merely a matter of formality to please the ideas of the budget maker, and actually do not affect the tax levy at all.

Some years ago I suggested to representative of a research bureau in Springfield that any reference to the water works as a *department* be left out of the budget; but that, if desired, special pages might be appended in the back portion of the budget, on which might be listed all self-supporting " public service enterprises " owned and operated by the municipality — such as, (*a*) water works, (*b*) gas plant, (*c*) electric plant, etc. — and under each could be shown the estimated and classified revenues and expenditures of same, as tentatively forecasted by the commissioners, trustees, or other bodies, in charge of such respective enterprises.

I am sure that this method would be far less confusing and more informing to the taxpayers and the general public, and is one of the things I had in mind when I suggested in my paper that a non-political body outside of the local city councils should be appointed to see that a complete separation should be maintained of such public service enterprises from the local political governing bodies, in order that a business administration instead of a political one might clearly show the proper relations of the two to all citizens at all times.

MR. LEONARD METCALF.* (*by letter*). Mr. Sherman's paper is a sound, concise and altogether admirable statement. It reflects the point of view of the banker or critical investor as well as of the engineer and the

*Of Metcalf and Eddy, Consulting Engineers, Boston.

water works operator. It is based upon a careful analysis of sound theory and of reliable records of water works operated intelligently and for long periods of years.

What the writer has to say is dictated rather by the desire to call attention to and emphasize certain facts, well known to the author, than to contribute essentially new ideas to the discussion; and thus to prevent the drawing of erroneous conclusions from some of the statements contained in the author's paper.

A water works plant is essentially a continuing property. Under normal conditions, it never dies unless the community which it serves itself dies. The structures constituting the physical part of the property, on the other hand, have limited lives. They wear out, are outgrown, or become obsolete from one cause or another within varying periods of time. They are replaced or superseded by new units or groups of structures. But there is an average period of existence of the structures, making up the physical plant, and this period is the one to which we refer as the average life of the plant.

Practically, individual groups of structures go out of service, for one reason or another, from time to time, and the investment involved by them must, on the one hand, be retired, repaid or amortized, and the new or superseding structures be covered by new investment; or, on the other hand, the maturing investment must be reinvested in the replacement of the existing or of the new and better adapted structure to do the work of the old structure. The property continues to live and to serve.

What generally happens is that from year to year, after the initial construction of the plant, the plant is extended to meet the growing needs of the community. But with the normal growth of cities in this country of 25 per cent. to 30 per cent. per decade, radical changes, involving major betterments and extensions, substantial replacements and some abandonments have to be made, at intervals of from 10 to 15 years, more or less, which in turn involve extraordinary expenditures. These expenditures are usually financed by bonds, in large measure if not wholly, because they are involved chiefly by the extensions and betterments and because they cover structures designed to meet the requirements of the future 15 or 20 or even 40 and 50 years hence rather than of the present moment.

To the extent that the work involves replacements or abandonments, the old investment must be retired. When retired, these old abandoned structures and the investment upon them are no longer of interest in subsequent valuations of the property.

The author deals, quite properly for simplicity and clearness of conception, with the *entire property* from its inception, rather than with the existing property only — that is with the original property less abandonments — because he is discussing the life of the investment or bonds issued against it, but the difference should be noted, since the usual problem faced in the valuation of water works, in dealing with the depreciation of

any property, is the determination of the depreciation upon the existing property, rather than the depreciation and abandonment upon the entire property from its inception.

The life histories of water works in this country as continuing properties, indicate that the structural property gradually decreases in value despite the increment in value involved by the minor annual betterments, until the average life cycle of the structures is reached, or until the minor betterments approximate the annual rate of depreciation, after which the so-called percentage condition, or full value less fair depreciation allowance of the structural property, remains constant on the average, fluctuating materially only at the more or less periodic times of reconstruction and betterment already referred to.

Thus it has been found that in the smaller, slower growing plants, their condition varies from 90 to 92 per cent., and the accrued depreciation upon existing structures only, often or perhaps generally ranges from 8 to 10 per cent. of the full value of these structures and that the amount of the abandoned property is relatively small, say from one-quarter to one-half in amount of the accrued depreciation upon the existing structures. But in the older plants serving the larger cities, their condition generally varies from 84 per cent. to 88 per cent. and the accrued depreciation from 12 per cent. to 16 per cent., and the amount of the abandonments ranges from one-half to the full amount of the accrued depreciation upon the existing structures.

Upon the thirteen typical plants cited by Mr. Sherman with respect to which full records were available, the accrued depreciation upon existing structures averaged 12.9 per cent; the abandoned structures averaged 7.7 per cent. of the existing structures only; the combined accrued-depreciation-upon-existing-structures and abandoned structures averaged 19.7 per cent. of the value of the combined existing and abandoned structures; and 22 per cent. of the existing structures only.

The conclusions reached by Mr. Sherman appear to be sound and to indicate the principles upon which this Association should stand, and which should be reflected in the laws of this state governing the financing of publicly owned water works.

DISCUSSION.

BY FREDERIC I. WINSLOW.

(By letter.)

[*September, 1922.*]

SHOULD WATER DEPARTMENTS BE MERGED WITH OTHER MUNICIPAL DEPARTMENTS?

The heart of the question raised by Mr. King's thoughtful paper lies in the vexed and unsettled problem of good city government. As Mr. Sherman states, the trouble bears hardest on the small towns where departments are merged, as the larger cities are compelled to have at least one competent head, or speedily suffer. It was said of the late Richard M. Croker, when he was "Boss" of New York City, that he was always careful to select competent engineers in order to actually prevent other appointees from disgracing his administration of affairs.

But whether the departments are consolidated or kept apart, the allocation of a water department surplus to any other department short of appropriations, will still be a custom.

To make the relation between the water and the other departments equitable, every gallon of water should be paid for to the water department. And the water department should be placed on the same footing as any private utility in the same town, so far as compensation for the use of the streets is concerned,

Along this line for many years after the Boston water works were installed, the revenue fell far short of meeting the expenses, and the city made annual appropriations to meet the deficits. Later when the water works did pay, an attempt was made to reimburse the city for this, but probably the water works is today in debt to the city for the last generation's deficits. So it is not wholly a one-sided question. From the standpoint of the water-works man, the departments should be maintained separately, but from the viewpoint of the municipal expert, all must be consolidated, and this apparent clashing can only be met by placing at the head of the water department a competent head. The subordinates cannot be expected to be above the ordinary level of the public employee in general.

Just now the City Manager idea seems to offer a solution of this question, but this departure appears to be falling into less favor in the eastern portion of the country, although fairly holding its own in the west and south.

WHY WE SHOULD INSPECT WATER WORKS EQUIPMENT.

[September, 1922.]

While it is a fact that the most disastrous and costly breaks in the water works system are usually due to a cause other than any remediable by any inspection at the foundry, this in no way minimizes the value of insistent inspection. "Eternal inspection is the price of satisfactory castings."

The "rigid bearing" has been responsible for more expensive accidents than any other one cause in the history of the water works of Boston as well as of other large cities.

The moral effect of the mere presence of an inert, even if honest, inspector may well be doubted, especially where the brains of the foundry exceed those of the inspector.

But Mr. Lally's paper is valuable in emphasizing the importance of inspection in all details and no municipality can afford to neglect this feature of water works maintenance.

ROBERT CARTER PITMAN COGGESHALL.

ROBERT CARTER PITMAN COGGESHALL was born in New Bedford, April 20, 1849. He was the son of Thomas and Caroline (Spooner) Coggeshall, being a direct lineal descendant in the eighth generation of John Coggeshall, who emigrated to this country from the town of Coggeshall, Essex, England, in September 1632, and settled in Roxbury and Boston, and later became one of the founders of the city of Newport, R.I., and at the union of the four towns, Newport, Portsmouth, Providence and Warwick was made the first president of that colony.

Mr. Coggeshall was named for the late Judge Robert Carter Pitman, an intimate friend of his father and mother.

He received a primary education at a private school, entered the Friends Academy at New Bedford and later became a student at the Rensselaer Polytechnic at Troy, N.Y.

He gave up the life of a student in the latter part of 1868 to become a clerk in the New Bedford post office, where his father was postmaster. Five months later he accepted a clerkship at the Bay State Glass Works at East Cambridge. The engineering instinct was in him, however. As a boy it had sought expression, and he had in vacation periods found employment in the surveying department of the Water Works, then first organizing and building the water system. In May, 1872, he returned to New Bedford to become draftsman, surveyor and general assistant to George B. Wheeler then superintendent of the Water Department. In 1877 he was elected city land surveyor. At that time, as the city was small (26 000) this position did not require full time service. Mr. Coggeshall therefore worked into a private engineering practice.

Mr. Coggeshall entered upon the office of superintendent of the New Bedford Water Works and clerk of the Water Board on June 9, 1881, succeeding William B. Sherman. He continued in that position until April 28, 1922, when he was retired on account of ill health. His business life literally covered the entire range of Water Works activities in New Bedford from their very beginning until the date of his retirement, covering the growth of the city from 20 000 to 131 000 population. During all this period he kept the water system well in advance of the growth of the city, showing great foresight in all his operations.

The following resolutions adopted by the Water Board at the time of his retirement express the esteem in which he was held by that Board.

"WHEREAS, the retirement of Robert C. P. Coggeshall from the offices of superintendent of the New Bedford Water Works and clerk of the Water Board, positions which he has filled with unusual ability for a period extending from 1881 to 1922, gives us an opportunity to express the esteem in which we hold him, and also our appreciation of his long and valued services; therefore be it

"RESOLVED, That we, the members of the Water Board of the city of New Bedford, take pleasure in placing upon the records of the Board our high estimation of his fidelity and ability in the conduct of the affairs of the department.

"The period of his service has been one of constant growth and expansion, including, as it does the time from 1894-1899, when the construction of the enlarged system of water supply was planned and completed.

"In his retirement he leaves behind a record of efficiency and farsightedness, which has few, if any, equals in the municipal service of any community in this commonwealth."

Mr. Coggeshall's life was also very intimately connected with that of this association. He and Mr. Frank E. Hall, then of Worcester, and Horace G. Holden, then of Lowell, met by chance at Lowell in February 1882. During that meeting the idea of forming an association of Water Works men, which had previously been suggested in 1877 by Mr. James W. Lyon but had made no further progress, was revived.

As a result of a great deal of correspondence twenty-one men assembled at Young's Hotel at Boston, April 19, 1882, when the matter was thoroughly discussed and a committee appointed to draft a constitution of by-laws. This constitution was adopted and the association organized June 21, 1882, at Young's Hotel with a membership of twenty-seven. Mr. Coggeshall was elected the first secretary at that meeting and served until 1884. He was president of the association in 1885-86 and again secretary from 1887-1895, when his city work increased to such an extent that it required his whole time, and he reluctantly relinquished this position.

He was the first editor of the JOURNAL when its publication was begun in 1886, and has always been one of the most energetic promoters of the association. He has always contributed liberally to the papers and discussions at the various meetings until within the last few years, when ill health has prevented his attendance. Even the failure of his health could not lessen his interest in the association, as some of the members, who had the pleasure of calling upon him during the recent convention in New Bedford, can testify.

On February 10, 1915, he was made an honorary member of this association.

He was also a member of the American Water Works Association, the Boston Society of Civil Engineers and the Connecticut Society of Civil Engineers.

He was very much interested in the Masonic fraternity, being a member of Star in the East Lodge A.F.& A.M., Adoniram R.A. Chapter, New Bedford Council R. & S.M., and Sutton Commandery K.T. He was also a member of Achushnet Lodge I.O.O.F. and the New Bedford Encampment. He was an earnest and active member of the First Congregational (Unitarian) Society where for years he rendered valuable service as a member of various committees. He was a member of the Wamsutta and Brook's Clubs as well as a trustee of the New Bedford Five Cent Savings Bank.

Mr. Coggeshall married Ledora Jenny on December 21, 1875. She died December 15, 1885. The two children of this marriage, Robert F., an electrical engineer in the employ of the General Electric Co., at Schenectady, N. Y., and Miss Helen R. of New Bedford are both living.

On April 29, 1890, he married Sarah Wall Almy of New Bedford, who also survives him.

He was an honor to this Association, and as a public official he always stood out as an example to the organization for his faithful, conscientious performance of duty.

His able counsel and genial smile will be greatly missed not only at the meetings of this association, but in many of the activites of his native city.

Respectfully submitted,

S. H. Taylor,
C. E. Davis,
Robert J. Thomas.

CHARLES E. PEIRCE.

Charles E. Peirce, son of Chauncy and Ellen M. Peirce, was born in Lincoln, R. I., June 8, 1848. In 1858 his parents moved to East Providence, R. I., where he continued to reside until his death on January 18, 1922.

On April 4, 1865, when scarcely eighteen years old, Mr. Peirce enlisted in Company H, Third Battalion, 15th U. S. Infantry, seeing service at Fort Adams, Mobile and Lookout Mountain before being discharged April 4, 1868. After his discharge from the Army his interest in military affairs was transferred to the State Militia and in 1884 he served as Sergeant Major, First Battalion of Cavalry. In later years he was very active in affairs of the G. A. R. and at the time of his death was Senior Vice-Commander, Department of Rhode Island, G. A. R.

In 1874, Mr. Peirce entered business as a contractor, mason and builder. In 1893, he constructed the pumping station of the East Providence Water Company and upon the completion of the water works in 1895, was elected superintendent, which position he continued to fill until he passed away.

On July 30, 1873, Mr. Peirce was married to Mary Wagner of Sharon Springs, N. Y. One son, Chauncy Peirce, who died in 1885 at the age of eleven, was the result of this union. Saddened by the death of his wife in 1912 and with no immediate family Mr. Peirce sought consolation and companionship in various fraternal organizations with which he was affiliated. He was a member of Redwood Lodge No. 35, A. F. & A. M., Solomon's Lodge of Perfection, R. I. Council Princes of Jerusalem, R. I.

Chapter of Rose Croix and R. I. Consistory, Reliance Lodge No. 34, I. O. O. F., and Howard Lodge No. 12, Knights of Pythias, of which latter body he was Past Grand Chancellor.

In civic affairs Mr. Peirce also took an active interest, serving at various times as chief of police, as a member of the Town Committee and as a member of the Town Council of his home town. Always active in matters pertaining to the conservation of bird and game life, in 1911 he was appointed a member of the State Bird Commission on which he served until 1920.

Elected to membership in the New England Water Works Association September 14, 1887, and a regular attendant at its meetings for nearly thirty-five years, his wise counsel, his never failing courtesy and helpful service brought to him a wide circle of friends among water works men. In his death the Association, the community and the State lose a worker for all that was best in many important human interests.

STEPHEN DE M. GAGE,
ALBERT E. DICKERMAN,
Committee.

PROCEEDINGS.

NOVEMBER MEETING.

BOSTON CITY CLUB,
Tuesday, November 14, 1922.

The President, Frank A. Barbour, in the chair.

The following were duly elected members of the Association:—

Active: John L. Morton, Water Commissioner, Plymouth, Mass.; Richard Sigfred Holmgren, Lynn, Mass. — 2.

Associate: Chase Metal Works, Waterbury, Conn., Brass Manufacturers; Fields Point Manufacturing Company, Providence, R. I., Manufacturers of Liquid Lime Bleach, Liquid Caustic Soda and Liquid Chlorine. — 2.

Dr. Richard Moldenke, of Watchung, N. J., gave a talk on "Some Engineering Aspects of Cast-Iron."

A paper on "Tars, New and Old," illustrated with the steropticon, was read by Mr. S. R. Church, Chemist and Manager of Oil and Tar Division, The Barrett Company, New York City.

Moving pictures were then exhibited showing the making of pipe by the sand method, and also showing the centrifugal process of casting pipe at the new plant of the United States Cast-Iron Pipe and Foundry Company, Birmingham, Ala.

MR. CHARLES W. SHERMAN. Mr. President, we have experienced a most remarkable meeting of this Association, and as a very slight expression of our appreciation of what has been given to us here I move a rising vote of thanks to Dr. Moldenke, to Mr. Church, and to the United States Cast-Iron Pipe and Foundry Company.

(The motion was duly seconded and unanimously carried by a rising vote.)

(*Adjourned.*)